Reactoare naturale și reactoare create de om. Asemănări, diferențe, lecții pentru reactorii artificiali de ultima generație

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•***EXPERIENTA***
43 de ani in domeniul nuclear:

- ***constructie CNE, fabricatie echipamente CNE, pregatire si autorizare operatori CNE, proiectare CNE, autorizare CNE – punere in functoiune si functionare CNE Cernavoda u1 si u2, dezafectare, analize de risc; la nivel national 28 ani , evaluari de securitate nucleara Cernavoda si programe noi de centrale nucleare (SMR)***
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ACTIVITATI
- ***Membru titular din 2014 si din 2019 secretar interimar al Diviziei de Logica si Modele in Stiinta (DLMFS) din cadrul Comitetului Roman de Istoria si Filozofia Stiintei si Tehnicii (CRIFST)– Academia Romana***
- ***Membru ESREDA – European Safety, Reliability & Data Association.***
- ***Consultant tehnic extern in proiecte IAEA si CE - securitate nucleara, tehnologii inovative, calculatoare quantice-roboti , analize de risc***
- ***Colaborator extern ("full academic scope"-) la conducerea de teze de doctorat in domeniul nuclear Universitatea Politehnica Bucuresti. Autor al cursului de master de analize de risc nuclear in cadrul programului Seneca, UBP-Facultatea Energetica, 1996-2000***
- ***Coordonator teze de doctorat asupra modelarii sistemelor energetice nationale si a securitatii alimentarii cu energie la Universitatea Tehnica Delft (2007-2010) si Universitatea Kaunas (2007-2010) cu colaborari ulterioare cu Brookhaven National Laboratory si Lithuanian Energy Institute .***
- ***Redactor sef (contract) domeniul risc industrial Safety Science - Elsevier (2009-2011)***
- ***Autor si coautor de carti si lucrari in domeniul securitatii nucleare si analizelor de risc, modelarea in fizica si energetica nucleara***

A. BACKGROUND

B. INTRODUCTION-ASSUMPTIONS

C. EVALUATION METHOD

D. LESSONS LEARNT

E. CONCLUSIONS

F. ANNEXES

A. BACKGROUND

1. Activitățile omului în crearea de **surse noi de energie în scopuri pașnice au ca obiect, de circa 70 de ani, energia nucleară de fisiun**e.
2. Reactorii nucleari produși de om până în prezent sunt **clasificați în generații, după criterii ce țin atât de performanțele economice, cât mai ales de cele de securitate nucleară.**
3. Din ambele perspective, **cu toate erorile și în ciuda unor accidente majore, omenirea și-a îmbunătățit tehnologia aceasta și produce artefacte de mare tehnicitate și cu grad crescut de siguranță.**
4. Și **totuși, omul nu a fost primul care a construit astfel ce surse de energie pe planetă.**
   - Acum **două miliarde și jumătate de ani, cel puțin un reactor natural**, de tip asemănător, a funcționat timp de circa două sute de mii de ani.
   - **Studierea acestui fenomen și compararea sa cu ceea ce cunoaștem din punct de vedere al fizicii teoretice și aplicate, ca și al tehnologiilor de fabricație**, referitor la proiectarea, construirea, exploatarea și dezafectarea unui astfel de reactor a avut și are un impact semnificativ asupra omului constructor de centrale de fisiune nucleară, inclusiv **generatia IV SMR**

5. What is energy and why do we need it? WE suggest an answer that **everything is ENERGY** and **we are not an exception**.This is actually valid for every type of known systems, whicch are modelled in the authors' vision as in Annexes 1 and 2. This is valid for subquantic and planet level systems, as well as for the whole cosmos. This is a possible way to describe reality, too.
6. **Developing a better understanding of energy systems** is important in our time. However, such approaches are to be developed in an environment of **changes in paradigms of physics both from the energy production and use point of view and from the epistemological perspectives**
7. **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.

B. INTRODUCTION-ASSUMPTIONS

- **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 were evaluated.

- **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** .

- 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.
- 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.

C. EVALUATION METHOD

- 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 presentation 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

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

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

Principle 2 (cont'd):

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- 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.

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

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

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

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)

Principle 3 (cont'd)

- 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.

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:

- Energy (E)
- Mass (m)
- Entropy (ψ)

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

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

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

These are optimal descriptors of each ES state

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

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Energy (E)
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$$E^{(k)} = E_0^{(k)} + \sum_{j=1}^{8} E_j^{(k)} * z_j^{(k)} \qquad (3)$$

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

These are optimal descriptors of each ES states 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.
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- 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) – A triadic set of syzygies defined the set of Realities

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

- The entropy has the following dominant syzygies for each state:
  - 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
- ES and their models define topological algebraic spaces, which might be represented as polyhedral type, describing their states and illustrating the optimal cases.
- The description of emergence/transformation of one source in another or of passage from one phase to another is based on the method presented before
- ES and their models exist in two types of interconnections, with:
  - Other natural phenomena
  - At a given level of civilization

ILLUSTRATION OF SOME ASPECTS OF APPLICATION AND INTERPRETATION FOR OKLO

- **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).**
- 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**

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

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Paradigms(cont'd)

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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.

D. LESSONS LEARNT

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

- 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**.

- **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").**

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

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).

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).
iii. **Radioactive radiosols 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 life cycle 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 hypercybernetics, 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 andomness (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?

E. CONCLUSIONS

- We need approaches to understand the **NES and MMES and our place in the cosmos** from this perspective is **based on an integrated view on the behavior itself and their models for the complex energy systems. Complex Energy Systems (CES) are considered to be topological systems as well as the models describing them.**

- **Acrtually Oklo and us are part of a bigger picture.**

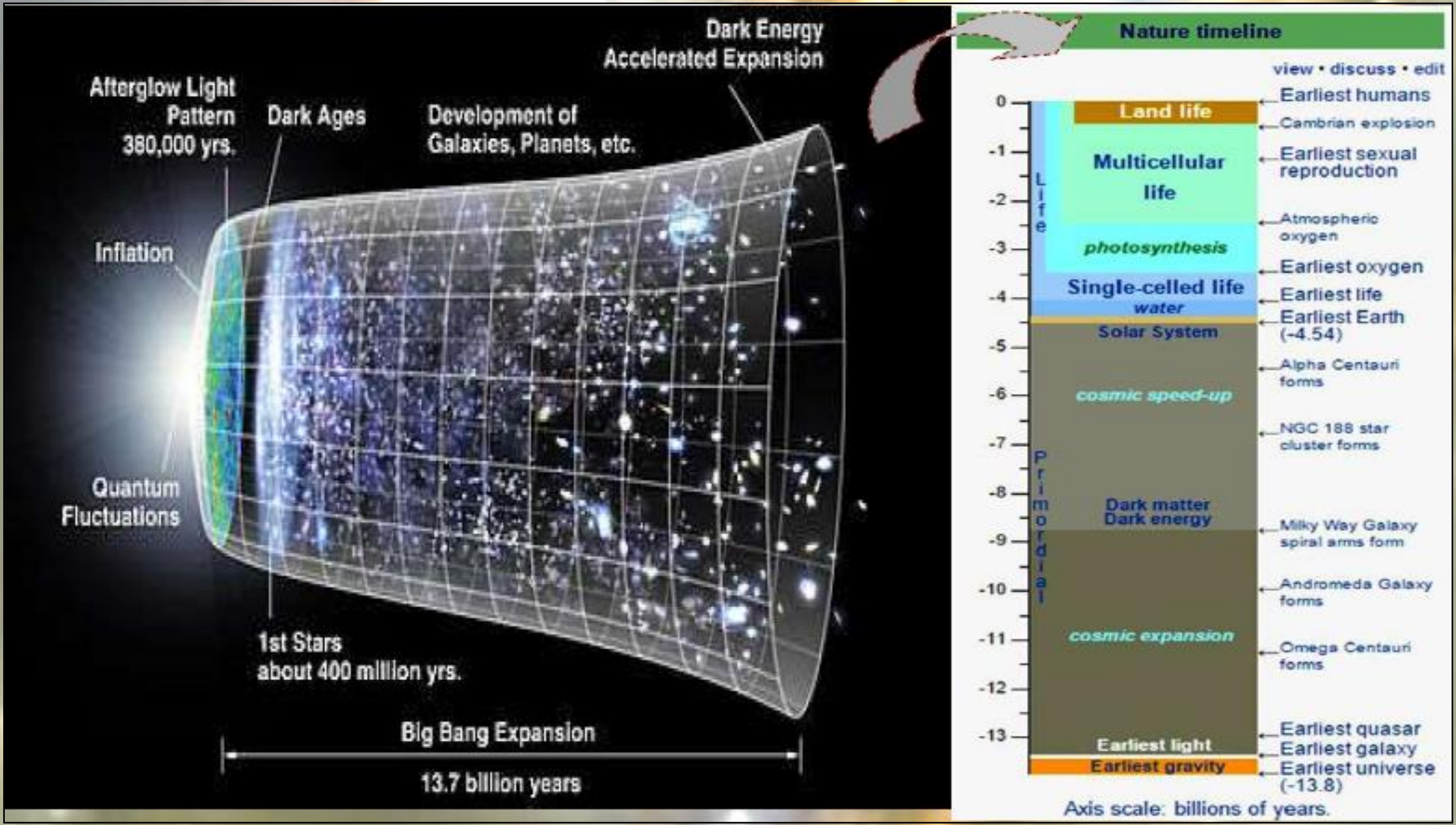
- **CES are from one side complex systems, called Complex Apoietic Topological Systems (CATS) complying with the requirements defined in previous works for them and form the other side they are topological systems and so are the models describing them**.

- An energy system exists in a space state, defined by a core of **unchanged features (called syzygies) described in a hyper complex apace. Energy systems interact at the same level (for a given type of energy – *lateral interface*) between them and with other systems challenging them**. They are also impacted from the other systems assumed in a continuous tight interconnection (“*up” and “down” interface)* by the intermede of impoact functions, defined as transfer functions in a hypercomplex space.

- The interactions between the **energy systems define a special type of cybernetic interaction in a hyper complex space, called *hyper cybernetics*. The usual cybernetics and both its second and third level, defined so far, become particular cases of a *hybercybernetic* behavior** and their models of a special type of topological complex systems, the energy systems of a given universe. Hyper cybernetics reflects the potential impact as a feedback and feed before of other universes.

F. ANNEXES

ANNEX 1


Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
380,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years
Nature timeline
view • discuss • edit
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
Life
Primordial
Land life
Multicellular
life
photosynthesis
Single-celled life
water
Solar System
cosmic speed-up
Dark matter
Dark energy
cosmic expansion
Earliest light
Earliest gravity
Earliest humans
Cambrian explosion
Earliest sexual
reproduction
Atmospheric
oxygen
Earliest oxygen
Earliest life
Earliest Earth
(-4.54)
Alpha Centauri
forms
NGC 188 star
cluster forms
Milky Way Galaxy
spiral arms form
Andromeda Galaxy
forms
Omega Centauri
forms
Earliest quasar
Earliest galaxy
Earliest universe
(-13.8)
Axis scale: billions of years.

Kardashev / Sagan scale civilization levels

Type	Tera watts	Level of used energy	Comments
I	4×10^{4} - $4x10^{5}$	Solar insolation to earth	Existing Earth level cca 4×10^{3} possible to reach type I in 100-200 years
II	4×10^{17}	Energy radiated by its own star	Few thousands years
III	4×10^{28}	Energy on the scale of its own galaxy	One million years

Group I Cosmic level	
[redacted]	
Group II Energy sources	
D-D fusion energy possible from worlds oceans	10^{31}
100-megaton H-bomb	10^{17}
Fission one ton of Uranium	10^{15}
Yearly solar emission	10^{17}
Burning a million tons of coal	10^{16}
Energy available from earth's fossil fuels	10^{23}
Exploding volcano (Krakatoa)	10^{16}
Thunderstorm	10^{14}
Group III Natural phenomena / significant human achievements	
Earth moving in orbit	10^{33}
Cretaceous-Tertiary extinction theory meteorite	10^{23}
Exploding volcano (Krakatoa)	10^{19}
Severe earthquake (Richter 8)	10^{18}
E = mc2 of 1 gram	10^{14}
Energy to put the space shuttle in orbit	10^{13}
Energy used in one year per capita U.S.	10^{12}

Type	Energy used	Energy density	Risk associated	Main features	Comments
0	1	2	3	4	5
I	Fusion	H	M	Conversion of matter-for instance helium into energy	For instance 280 kg of hydrogen into helium per second = cca 8.9×106 tons/year
	Antimatter-matter collisions	H	H	Entire rest mass of the particles converted toradiant energy.	Energy released per mass = cca four orders of magnitude greater than from nuclear fission
	Renewable energy	L	L	Solar cells Earth ground based	Very limited impact (VLI)
		L	L	Wind ground based	VLI
		L	L	Hydro	VLI
		M	M	Earth space based solar satellites	Possible to lead to type I if all the solar power is used
II	Earth star/solar space	H	H	Star/solar space based solar satellites	Earth based stations
	Stellar mass into a black hole	H	VH	Feed stellar mass into a black hole	Collect photons emitted by the accretion disc
	Penrose process	H	VH	Penrose process	Capture photons escaping from the accretion disc, reducing a black hole's angular momentum
	Star lifting	VH	VH	Remove a substantial portion of a star's matter	The process to remove portion of a star's matter is done in a controlled manner.
	Recycled antimatter	VH	VH	Antimatter as industrial byproduct	Antimatter as industrial byproduct of engineering processes - for ex star lifting and recycled
	Absorb fraction of stars in a large number of stars	VH	VH	Absorb fraction of the output of each star.	In multiple-star systems absorb fraction of the output of each star
III	Sources for type II for more galaxies	VH	VH	ditto II but applied to all stars of one or more galaxies	As per type II
	Black holes energy	VH	CT	Use the energy released from black holes	Black holes at the center of many galaxies
	White holes energy	VH	CT	from collecting the matter propelling outwards	White holes provide energy from collecting the matter propelling outwards
	Gamma ray bursts	CT	CT	Capture energy of gamma-ray bursts	Capture energy of gamma-ray bursts - power source
	Quasars	CT	CT	Emissions from quasars comparable to small active galaxies	Emissions from quasars comparable to small active galaxies -power source

ANNEX 2

O posibila teorie a sistemelor energetice cu concluzii posibile

- Tintim spre spre sisteme energetice robuste la provocari, construite fractalic la toate nivelurile

- Se aplica si la cele despre care intentionam sa discutam…

s y s t e m s

Subquantic	SQ=SYS7
Quantic	Q =SYS8
Molecular	M =SYS9
Molecular life	ML=SYS1
Planetary	P =SYS2
Planetary life	PL =SYS3
Planetary life intelligent	**PLI =SYS0**
Galaxy	G =SYS4
Cosmic	C =SYS5
Cosmic life	CL =SYS6
Cosmic intelligent	**CLI =SYS10**

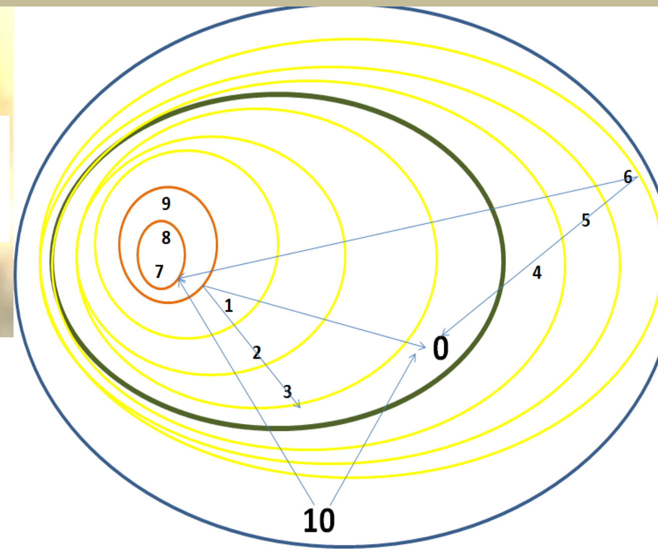
For one given case

$$s^{(k)} = \sum_{l=0}^{8} \sigma_l^{(k)} + \sum_{l=0}^{8} \omega * i_l^{(k)}$$

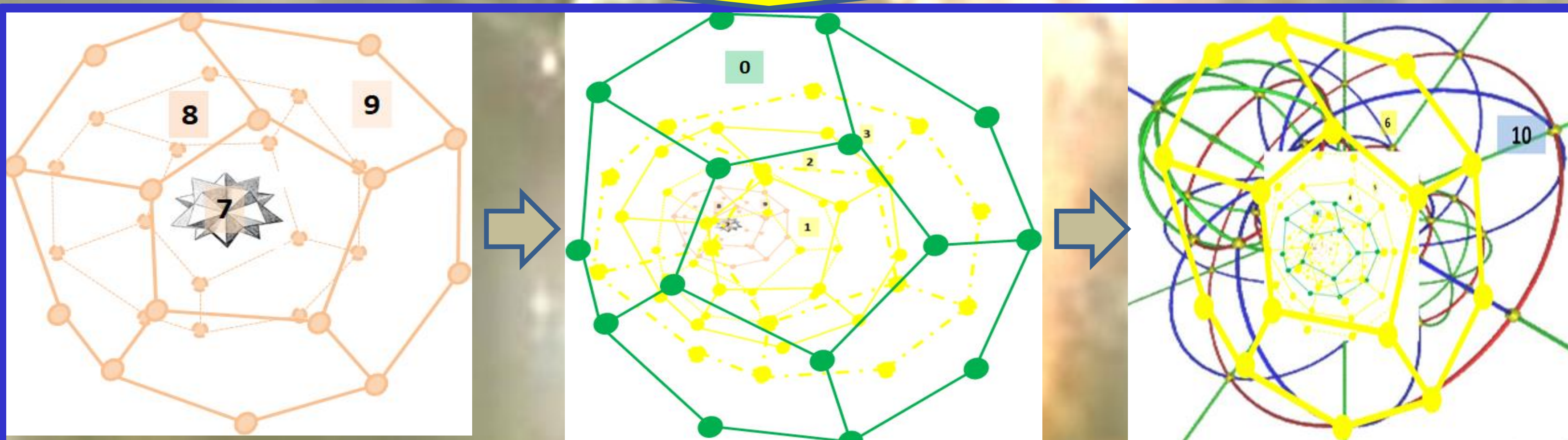
$$E^{(k)} \equiv \sum_{l=0}^{8} E_l^{(k)} i_l^{(k)}$$

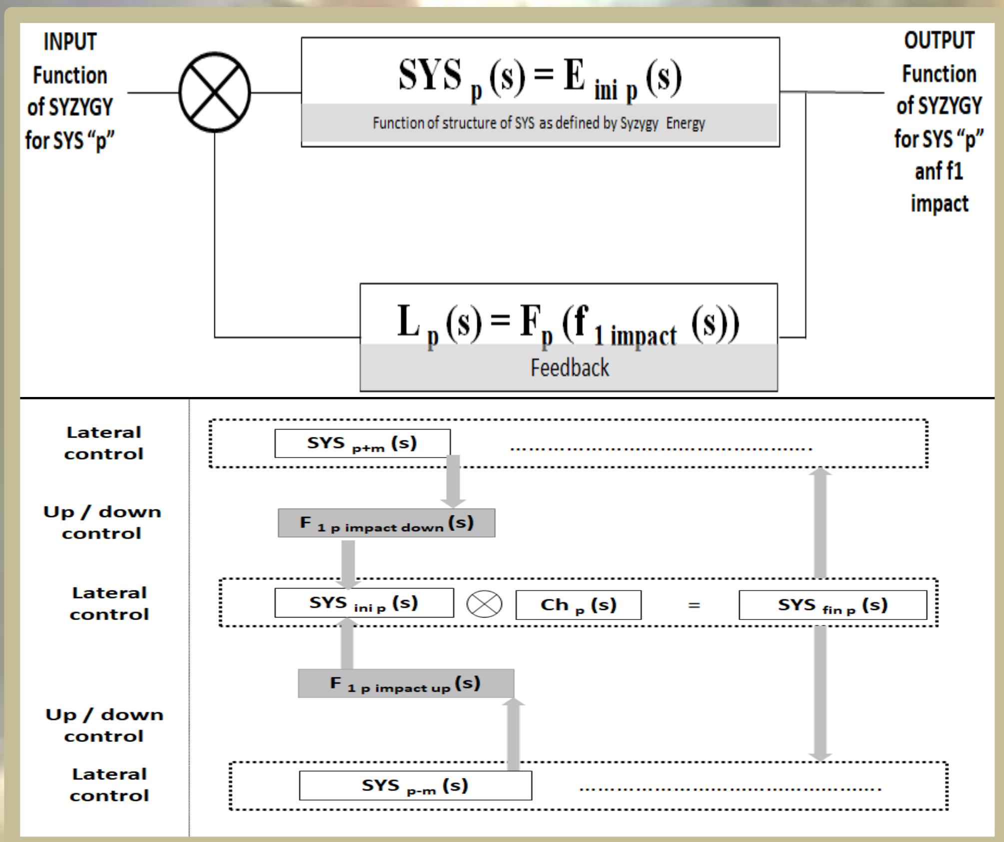
$$m^{(k)} \equiv \sum_{l=0}^{8} m_l^{(k)} i_l^{(k)}$$

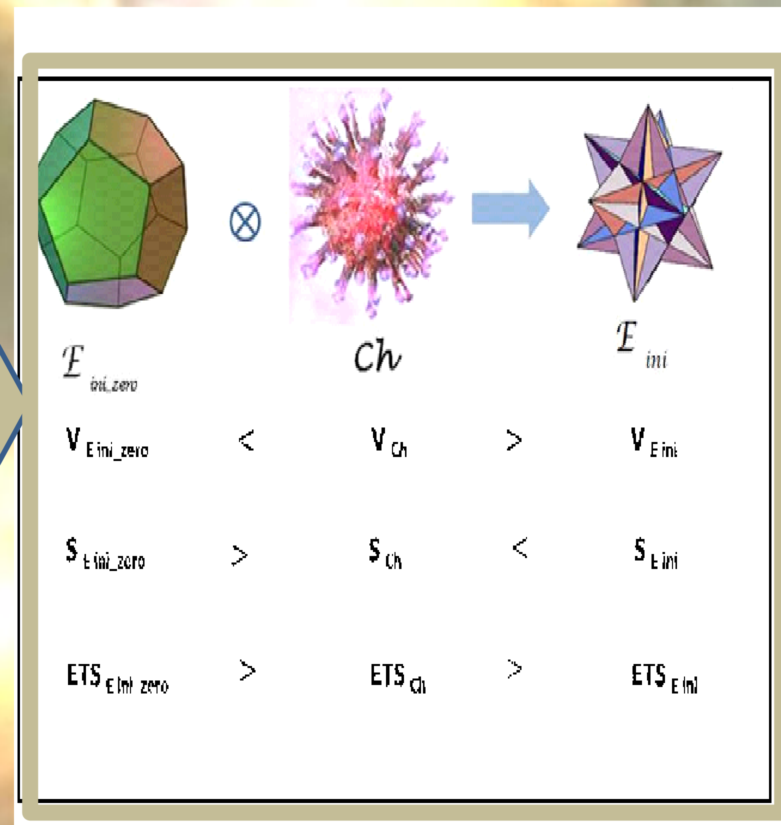
$$\psi^{2\,(k)} \equiv \sum_{l=0}^{8} \psi^{2}{}_l^{(k)} i_l^{(k)}$$

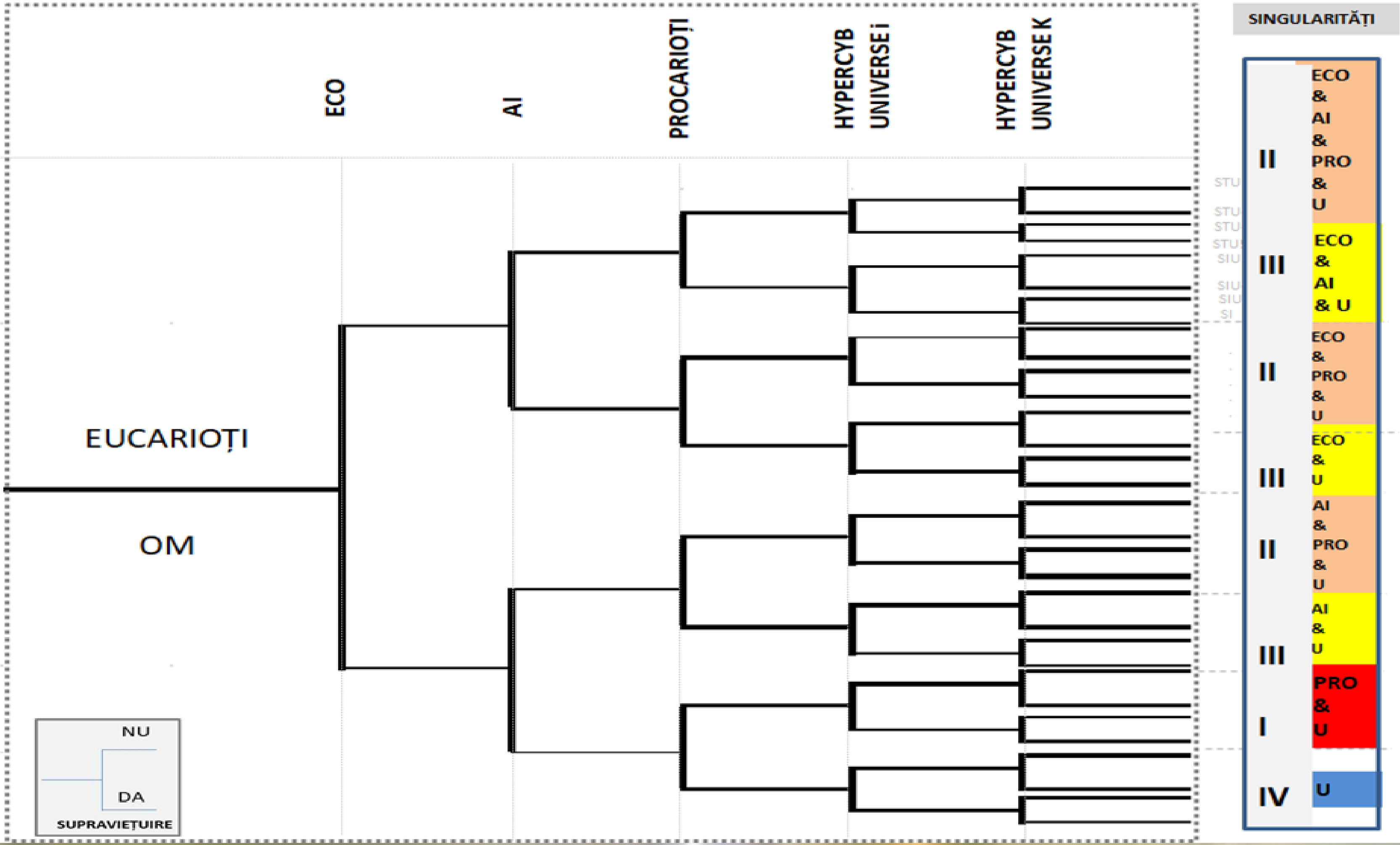


s p a c e st at e s




INPUT Function of SYZYGY for SYS "p"
SYS p (s) = E ini p (s)
Function of structure of SYS as defined by Syzygy Energy
OUTPUT Function of SYZYGY for SYS "p" anf f1 impact
L p (s) = F p (f 1 impact (s))
Feedback
Lateral control
Up / down control
Lateral control
Up / down control
Lateral control
SYS p+m (s)
F 1 p impact down (s)
SYS ini p (s)
Ch p (s)
=
SYS fin p (s)
F 1 p impact up (s)
SYS p-m (s)


E ini_zero
Ch
E ini
V E ini_zero
<
V Ch
>
V E ini
S E ini_zero
>
S Ch
<
S E ini
ETS E ini zero
>
ETS Ch
>
ETS E ini


ECO
AI
PROCARIOȚI
HYPERCYB UNIVERSE i
HYPERCYB UNIVERSE K
EUCARIOȚI
OM
NU
DA
SUPRAVIEȚUIRE
SINGULARITĂȚI
II
ECO & AI & PRO & U
III
ECO & AI & U
II
ECO & PRO & U
III
ECO & U
II
AI & PRO & U
III
AI & U
I
PRO & U
IV
U

Singularități UPSCAT posibile evoluții

Problema este că gestionarea provocărilor poate duce la singularitate reală, fără adaptare și deci la dispariția UPSCAT. Cu cât evoluăm mai mult, cu atât ne va fi mai greu să nu ne autodistrugem, dacă nu ne modificăm fundamental.

UPSCAT (OM) are patru categorii de posibile singularități Combinate cu impact de pe alte tărâmuri (galactic, cosmic, multiunivers)

I Biologice
II Biologice și (Ecologice și/sau din cauze AI)
III Ecologice și/sau AI

Impact exclusiv de pe alte tărâmuri (galactic, cosmic, multiunivers)

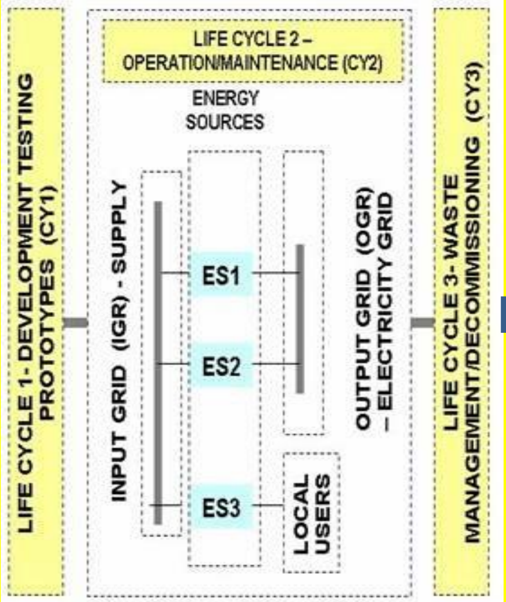
ANNEX 3

Scenarii orientate spre asigurarea securitatii energetice- <u>REZILIENTA / ROBUSTETEA</u>

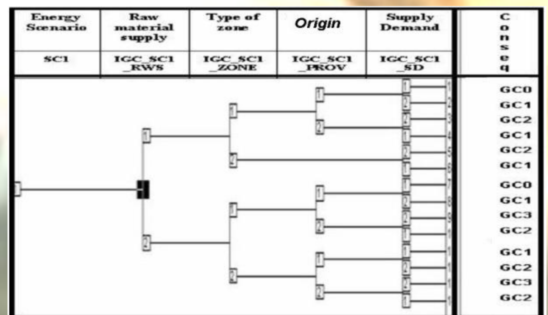
Exprimata de exemplu prin capacitatea de a supravietui in regim apropiat de normal dupa orice fel de provocari

sistemelor nationale, regionale

Modelul surselor si retelelor



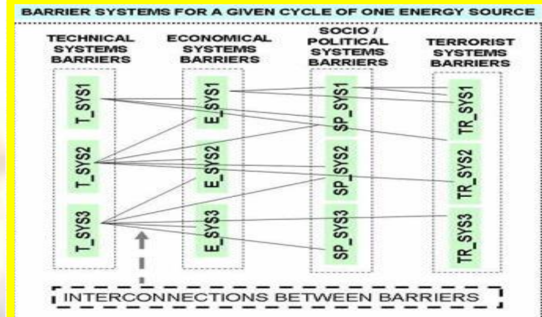
Conditii initiale



Provocari/perturbari

IE_ES1_CY2_SP1	Initiating Event SP1 for SC1 ES1 Cy2
IE_ES1_CY3_SP1	Initiating Event SP1 for SC2 ES1 CY3
IE_ES2_CY1_SP1	Initiating Event SP1 for SC2 ES2 Cy2
IE_ES2_CY2_SP1	Initiating Event SP1 for SC3 ES2 Cy2
IE_ES3_CY2_SP1	Initiating Event SP1 for SC3 ES3 Cy2
IE1_ES1_CY2_E1_0	IE ES1_0 for SC1 ES1 Cy2
IE1_ES1_CY2_E1_1	IE ES1_1 for SC1 ES1 Cy2
IE1_ES1_CY2_E1_2	IE ES1_2 for SC1 ES1 Cy2
IE1_ES1_CY2_T1_0	IE T1_0 for SC1 ES1 Cy2
IE1_ES1_CY2_T1_1	IE T1_1 for SC1 ES1 Cy2
IE1_ES1_CY2_T1_2	IE T1_2 for SC1 ES1 Cy2

Interfete interne



	T1	T2	T3	E1	E2	E3	SP1	SP2	SP3
T1	1	0	0	1	0	0	0	0	0
T2	0	1	0	1	1	1	1	1	1
T3	0	0	1	1	1	1	1	1	1
E1	1	1	1	1	0	0	0	1	1
E2	0	1	1	0	1	0	1	1	1
E3	0	1	1	0	0	1	1	1	1
SP1	0	1	1	0	1	1	1	0	0
SP2	0	1	1	1	1	1	0	1	0
SP3	1	1	1	1	1	1	0	0	1

	SURV3 MCS				
6	ES1_CY3_E_SYS1	GC2_SF	IE_SC1_ES2_CY3_TR1		
31	ES2_CY3_E_SYS1	ES2_CY3_E_SYS_SWSF	GC2_SF	IE_SC1_ES2_CY3_TR1	
33	ES2_CY3_SP_SYS1	ES2_CY3_SP_SYS_SWSF	GC2_SF	IE_SC1_ES2_CY3_TR1	
45	GC2_SF	IE_SC1_ES2_CY3_TR1	IGR_CY3_E_SYS1	IGR_CY3_E_SYS_SWSF	
77	GC2_SF	IE_SC1_ES2_CY3_TR1	OGR_CY3_SP_SYS1	OGR_CY3_SP_SYS_SWSF	
78	GC2_SF	IE_SC1_ES2_CY3_TR1	OGR_CY3_E_SYS1	OGR_CY3_E_SYS_SWSF	
95	ES1_CY3_E_SYS1	GC1_SF	IE_SC1_ES2_CY3_TR1		
435	GC2_SF	IE_SC1_ES2_CY3_TR2	IGR_CY3_SP_SYS1	IGR_CY3_SP_SYS_SWSF	
442	ES2_CY3_SP_SYS1	ES2_CY3_SP_SYS_SWSF	GC2_SF	IE_SC1_ES2_CY1_TR2	
2651	ES3_CY3_SP_SYS1	ES3_CY3_SP_SYS_SWSF	GC1_SF	IE_SC1_ES2_CY3_T2	
2669	ES1_CY3_E_SYS2	GC1_SF	IE_SC1_ES2_CY3_T2		
3811	ES2_CY3_E_SYS1	ES2_CY3_E_SYS_SWSF	GC0_SF	IE_SC1_ES2_CY3_T1	
4141	ES1_CY3_SP_SYS2	ES1_CY3_SP_SYS_SWSF	GC2_SF	IE_SC1_ES2_CY3_TR2	
6952	ES3_CY3_SP_SYS2	ES3_CY3_SP_SYS_SWSF	GC0_SF	IE_SC1_ES2_CY3_T1	
10034	ES1_CY3_T_SYS1	ES1_CY3_T_SYS2	ES3_CY3_T_SYS_SWSF	GC0_SF	IE_SC1_ES2_CY3_T1
507	ES2_CY3_E_SYS1	ES2_CY3_E_SYS_SWSF	GC2_SF	IE_SC1_ES2_CY1_TR2	
508	ES2_CY3_E_SYS1	ES2_CY3_E_SYS_SWSF	GC2_SF	IE_SC1_ES2_CY2_TR2	

	Components and their occurrence / failure impact for a SES state of type SURV3 (as defined in Table 1)	Rank of Impact	Confidence in results	Group of impact
	Failure of the barrier defined by System 2 of TR type. for ES2 in cycle CY1	H	L	I – HL
A	Failure of the barrier defined by System 2 of SP type. for ES2 in cycle CY2	H	L	
	Failure of the barrier defined by System 2 of T type. for ES1 in cycle CY2	H	L	
	Failure of the barrier defined by System 2 of E type. for ES1 in cycle CY3	H	M	II – HM
B	Occurrence of an IE (Challenge) to OGR of TR2 type in cycle CY2	H	M	
	Failure of the barrier defined by System 1 of TR type. for ES1 in cycle CY1	H	M	
	Occurrence of an IE (Challenge) to OGR of T2 type in cycle CY2	M	L	III – ML
C	Failure of the barrier defined by System 1 of T type. for OGR in cycleCY2	M	L	
	Failure of the barrier defined by System 2 of T type. for ES3 in cycle CY1	M	L	
	Initial condition of worst type (GC3)	H	H	IV – HH
D	Failure of the barrier defined by System 2 of SP	H	H	

		SURV3 IMP	Impact rank	Uncertainty results	Groups
137	ES2_CY1_TR_SYS2	Failure of System 2 ES2 TR Cy1	H	L	I=HL
159	IGR_CY2_E_SYS2	Failure of System 2 IGR E Cy2	H	L	
166	ES2_CY2_SP_SYS2	Failure of System 2 ES2 SP Cy2	H	L	
167	IE_SC1_OGR_CY3_SP2	IE SP2 for SC1 OGR Cycle3	H	L	
285	ES1_CY2_T_SYS2	Failure of System 2 ES1T Cy2 considering switches	H	L	
35	ES1_CY3_E_SYS2	Failure of System 2 ES1 E Cy3	H	M	II=HM
39	IE_SC1_OGR_CY2_TR2	IE TR2 for SC1 OGR Cycle2	H	M	
145	ES3_CY1_TR_SYS1	Failure of System 1 ES3 TR Cy1	H	M	
180	ES1_CY1_E_SYS1	Failure of System 1 ES1 E Cy1 considering switches	H	M	
115	IE_SC1_OGR_CY2_T2	IE T2 for SC1 OGR Cycle2	M	L	III=ML
116	IE_SC1_IGR_CY2_T2	IE T2 for SC1 IGR Cycle2	M	L	
258	OGR_CY2_T_SYS1	Failure of System 1 OGR T Cy2	M	L	
292	ES3_CY1_T_SYS2	Failure of System 2 ES3 T Cy1	M	L	
3	GC3_SF	Weight of chossing GC3	H	H	IV=HH
98	ES3_CY2_SP_SYS_SWSF	Split fraction not considering switches for failure of Systems ES3 SP Cy2	H	H	

SES - General[2] Survivability Group (SES - GSG)	Short Description of General Survivability Group	SES - Specific Survivability Subgroup Combination of categories defined in Table 2 (Binning)
SURV 0	Very Low Impact leading to no significant follow up corrective actions needed (NCO)	T0 E0 E1 T1
SURV 1	Small Impact leading to Minor follow up corrective actions needed (CO1)	E2 T2 E0T1 E0E1 E0T1 E0T0 E0T1 E1T0
SURV 2	Medium Impact leading to Some Important follow up corrective actions needed (CO2)	E1E2 E1T1 E1T2 E2T1
SURV 3	High Impact leading to Major follow up corrective actions needed (TCO)	E2T2

	Components and their occurrence / failure impact for a SES state of type SURV3 (as defined in Table 1)	Rank of Impact	Confidence in results	Group of impact
	Failure of the barrier defined by System 2 of TR type, for ES2 in cycle CY1	H	L	
A	Failure of the barrier defined by System 2 of SP type, for ES2 in cycle CY2	H	L	I - HL
	Failure of the barrier defined by System 2 of T type, for ES1 in cycle CY2	H	L	
	Failure of the barrier defined by System 2 of E type, for ES1 in cycle CY3	H	M	
B	Occurrence of an IE (Challenge) to OGR of TR2 type in cycle CY2	H	M	II - HM
	Failure of the barrier defined by System 1 of TR type, for ES1 in cycle CY1	H	M	
	Occurrence of an IE (Challenge) to OGR of T2 type in cycle CY2	M	L	
C	Failure of the barrier defined by System 1 of T type, for OGR in cycle CY2	M	L	III - ML
	Failure of the barrier defined by System 2 of T type, for ES3 in cycle CY1	M	L	
	Initial condition of worst type (GC3)	H	H	IV - HH
D	Failure of the barrier defined by System 2 of SP type, for ES1 in cycle CY2	H	H	

Challenge consists of a failure of barrier 2 of socio- political type for ES1, i.e. nuclear (e.g. failure of reaching consensus between government, industry and public regarding the continuation of nuclear power plant prediction (cycle 2). In this scenario, the decision-maker could shut down the nuclear plant, but this could have serious repercussions to the entire survivability of the whole energy system, as nuclear is one of the important sources of the energy mix. However, this could lead to even worse public reaction when they will realize that their everyday lives may be drastically changed due to lack of electricity. Thus, as this scenario is of high-risk and high confidence, the decision-maker may have no other choice but to speedily re-open dialogue with the public to seek consensus on the best course of action

ANNEX 4

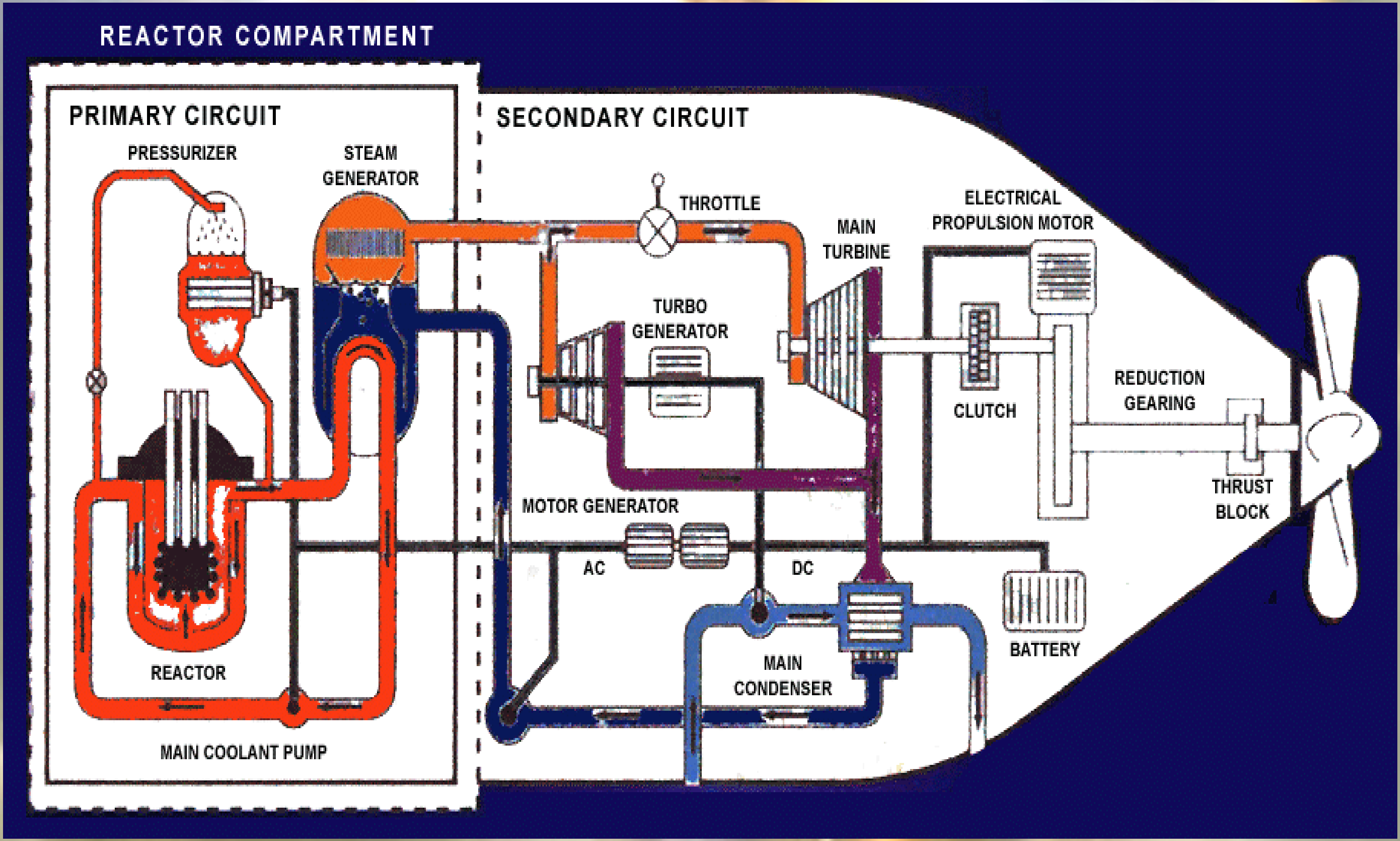
PRINCIPALELE PROVOCARI ALE FIZICII SI ENERGETICII NUCLEARE ACTUALE

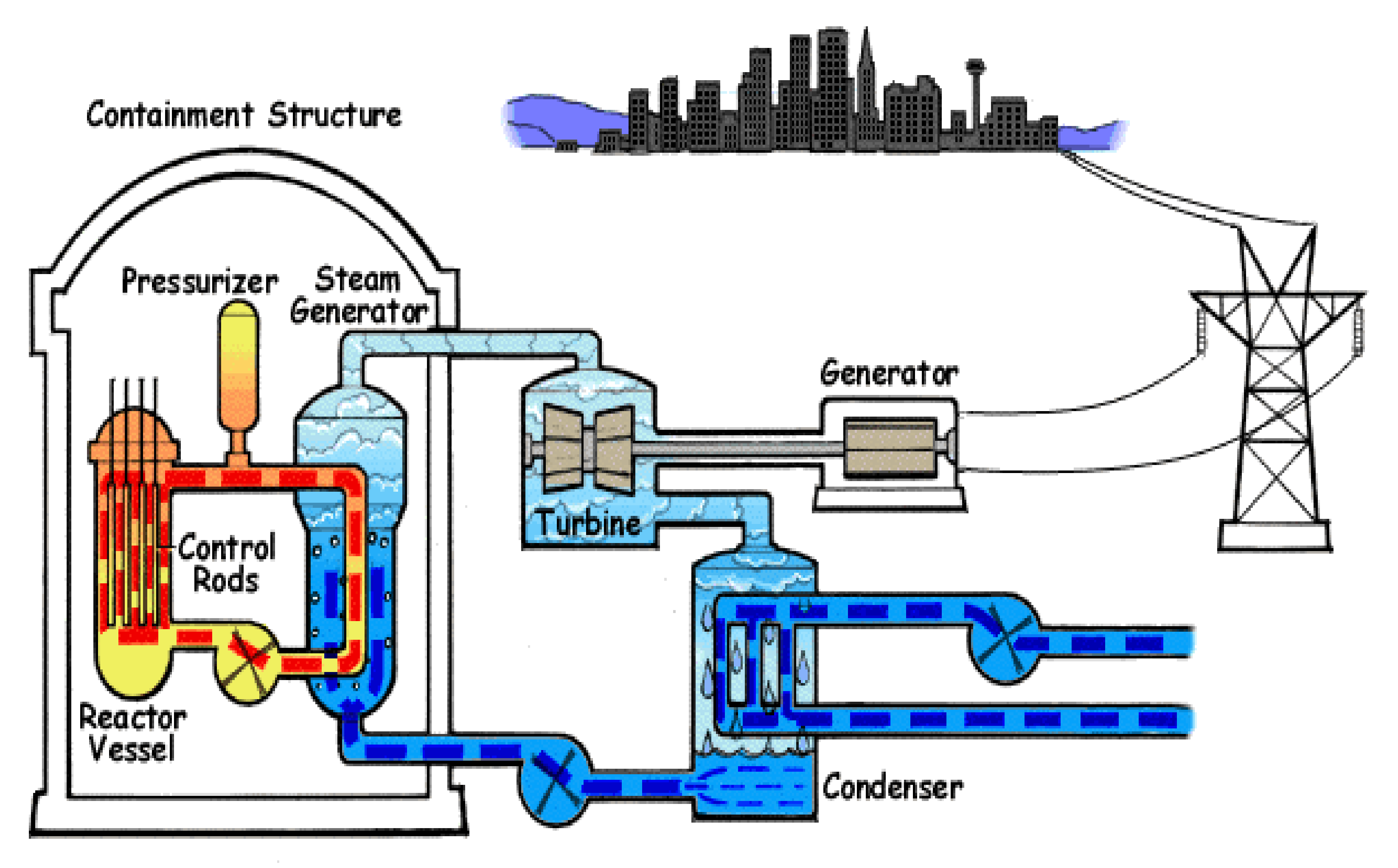
MONDIALE SI NATIONALE

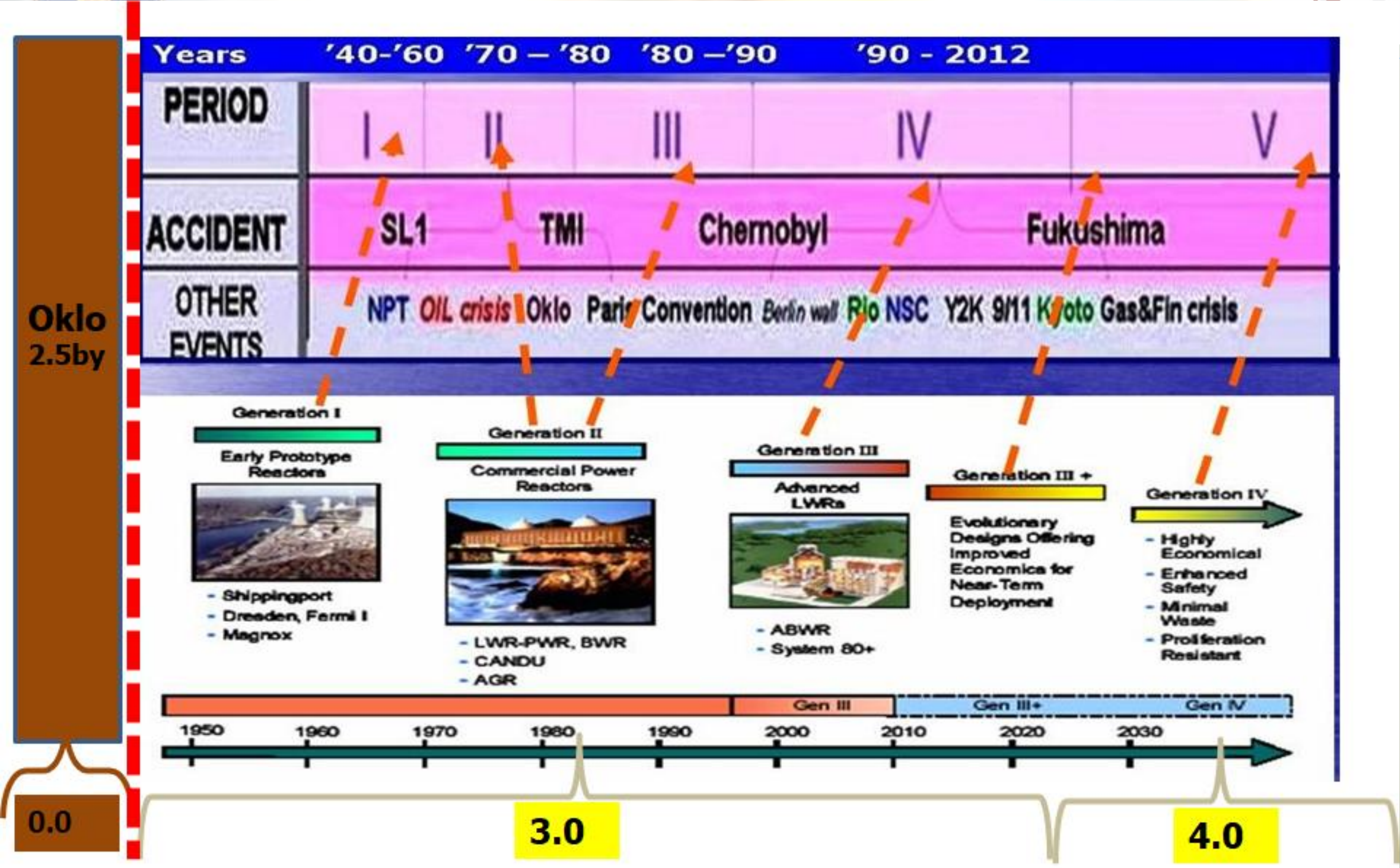
1. **Rezilienta/ Robustetea sistemelor energetice nationale si utilizarile locale ale diverselor forme de energie**
2. **Sistemele energetice necesita sa fie gandite fractalic, autoreglabile/apoietice pe tot ciclul de viata si cuprinzand materiile prime-exploatare- dezafectare etc, impreuna cu consumatorii**
3. **Oikonomia ar trebui sa fie un principiu fractalic si autoreglabil**
4. **Ciclul de viata sa cuprinda cercetarea, testarea si functionarea ceea ce in energetica neceesita timpi indelungati**
5. **Adaptarea la utilizari diverse, dinamice ale energiei sub diverse forme, in diverse locatii, solutii de stocare**

6. **Prezenta indepartare de modelele din natura/cosmos – de ex Oklo sau fuziunea nucleara si necunoscutul descoperirilor/dezamagirilor ar trebui considerate**
7. **Dilemele si problemele surselor de energie, de exemplu cele ale reactorilor de fisiune** - *Sursele de energie vazute ca parte a unui ciclu si nu doar sursa. Energetica nucleara de fisiune necesita de exemplu raspuns la cum arata ciclul de combustibil si integrarea acestei surse in diverse locatii*
8. **Presiunea gasirii de solutii pentru supravietuire- la scara de comunitati, dar si planetara - pericolul atingerii momentului singularitatii omenirii ca sistem de energie biologica constienta planetara (biologic, IA, socio-politic, cosmic)**

9. **Raspunsuri la accidentele majore si o orientare mai buna in definirea paradigmelor in domeniu**
10. **Promovarea de tehnologii noi aliniate la rezultate recente din fizica teoretica si aplicata:**
    i. **Utilizarea de noi tehnologii – nanotehnologii, Proiectare/operare cu utilizarea spatiului virtual, considerarea evolutiei generatiilor umane, robotizare/IA inclusiv calculatoare cuantice etc.**
    ii. **Rezultate noi in cercetarea de materiale si filiere cunoscute, dar prentru care tehnologiile nu permiteau pana acum utilizarea lor comerciala**
    iii. **Noi rezultate din abordari / recalculari / remodelari din fizica teorica asupra fenomenelor de baza ale fisiunii (sectiuni eficace, zona activa recalculate etc)**
11. **Implementarea lectiilor marilor accidente**

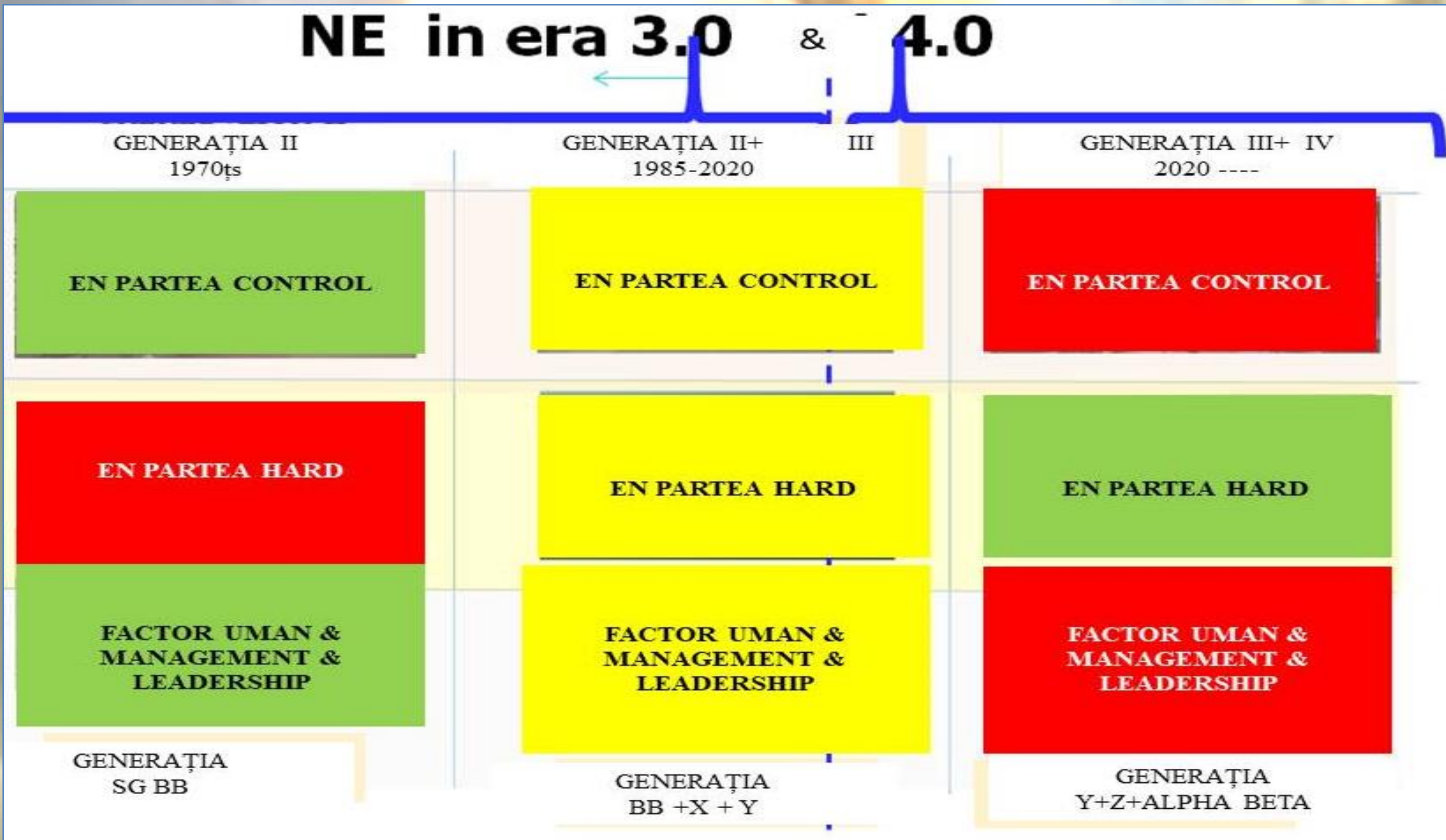

REACTOR COMPARTMENT
PRIMARY CIRCUIT
PRESSURIZER
STEAM GENERATOR
REACTOR
MAIN COOLANT PUMP
SECONDARY CIRCUIT
THROTTLE
MAIN TURBINE
ELECTRICAL PROPULSION MOTOR
TURBO GENERATOR
CLUTCH
REDUCTION GEARING
THRUST BLOCK
MOTOR GENERATOR
AC
DC
MAIN CONDENSER
BATTERY


Containment Structure
Pressurizer
Steam Generator
Generator
Control Rods
Turbine
Reactor Vessel
Condenser


Oklo
2.5by
0.0
Years '40-'60 '70 – '80 '80 –'90 '90 - 2012
PERIOD I II III IV V
ACCIDENT SL1 TMI Chernobyl Fukushima
OTHER EVENTS NPT OIL crisis Oklo Paris Convention Berlin wall Rio NSC Y2K 9/11 Kyoto Gas&Fin crisis
Generation I
Early Prototype Reactors
- Shippingport
- Dresden, Fermi I
- Magnox
Generation II
Commercial Power Reactors
- LWR-PWR, BWR
- CANDU
- AGR
Generation III
Advanced LWRs
- ABWR
- System 80+
Generation III +
Evolutionary Designs Offering Improved Economics for Near-Term Deployment
Generation IV
- Highly Economical
- Enhanced Safety
- Minimal Waste
- Proliferation Resistant
Gen III
Gen III+
Gen IV
1950
1960
1970
1980
1990
2000
2010
2020
2030
3.0
4.0

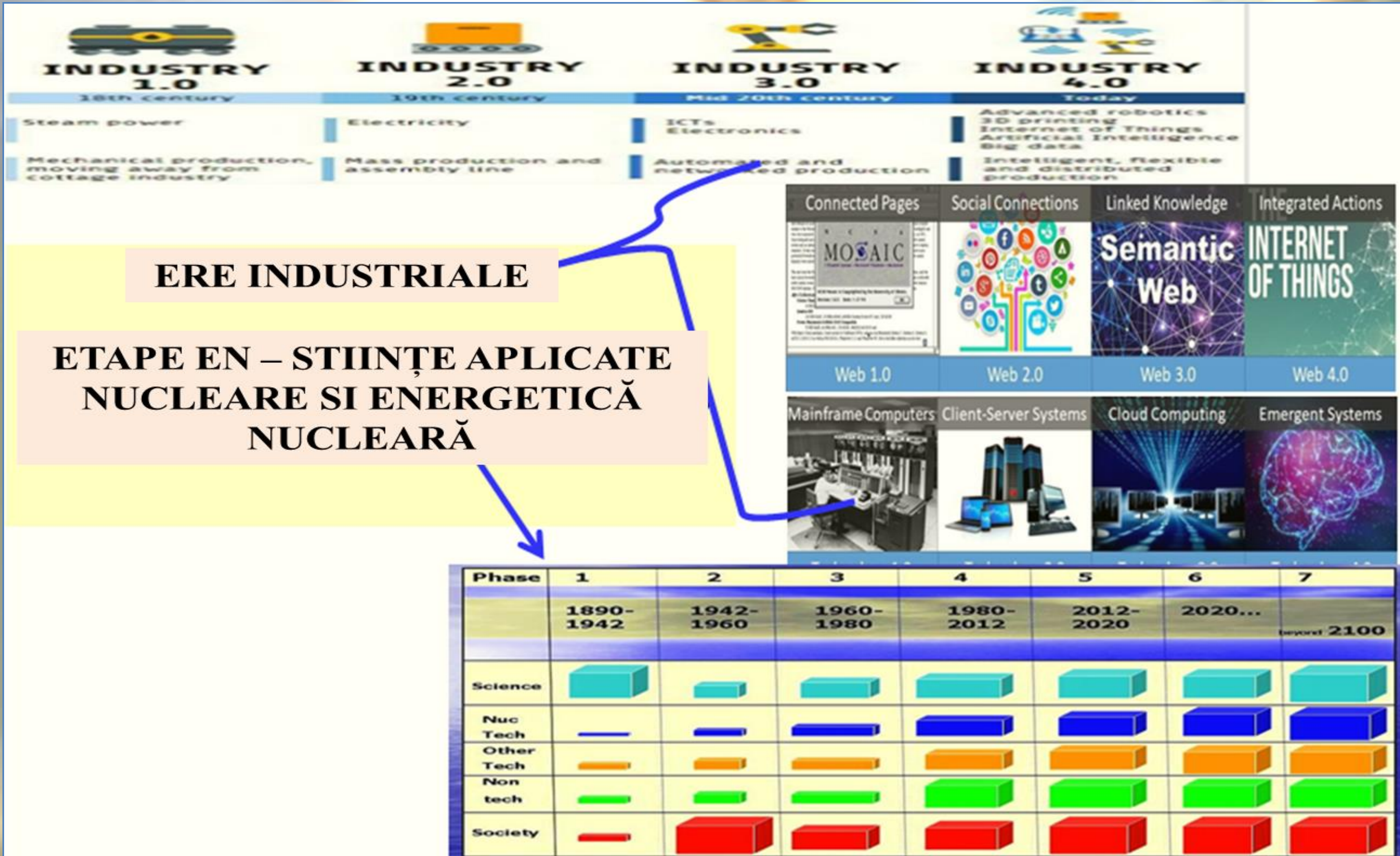
12. Raspunsuri la probelemele specifice nationale

i. de stabilitate, rezilienta SEN generate de masurile de atingere a tintelor de protectie climatica, ce necesita oprirea a cca 2000 MW de centrale termice pe carbune
ii. Asigurare a functionarii in regim de reglaj de frecventa in SEN
iii. Proiectarea functionarii SMR pe platforme energetice complexe, inclusiv cu regenerabile, pentru a intruni avantajele diverselor surse.
iv. Utilizarea la maxim de resurse – inclusiv umane si instalatii disponibilizate prin oprirea centralelor pe carbune
v. Sprijinirea industriei si cercetarii nationale nucleare
vi. Integrarea in procesul de reinnoire tehnologica in domeniu - Industry 4.0

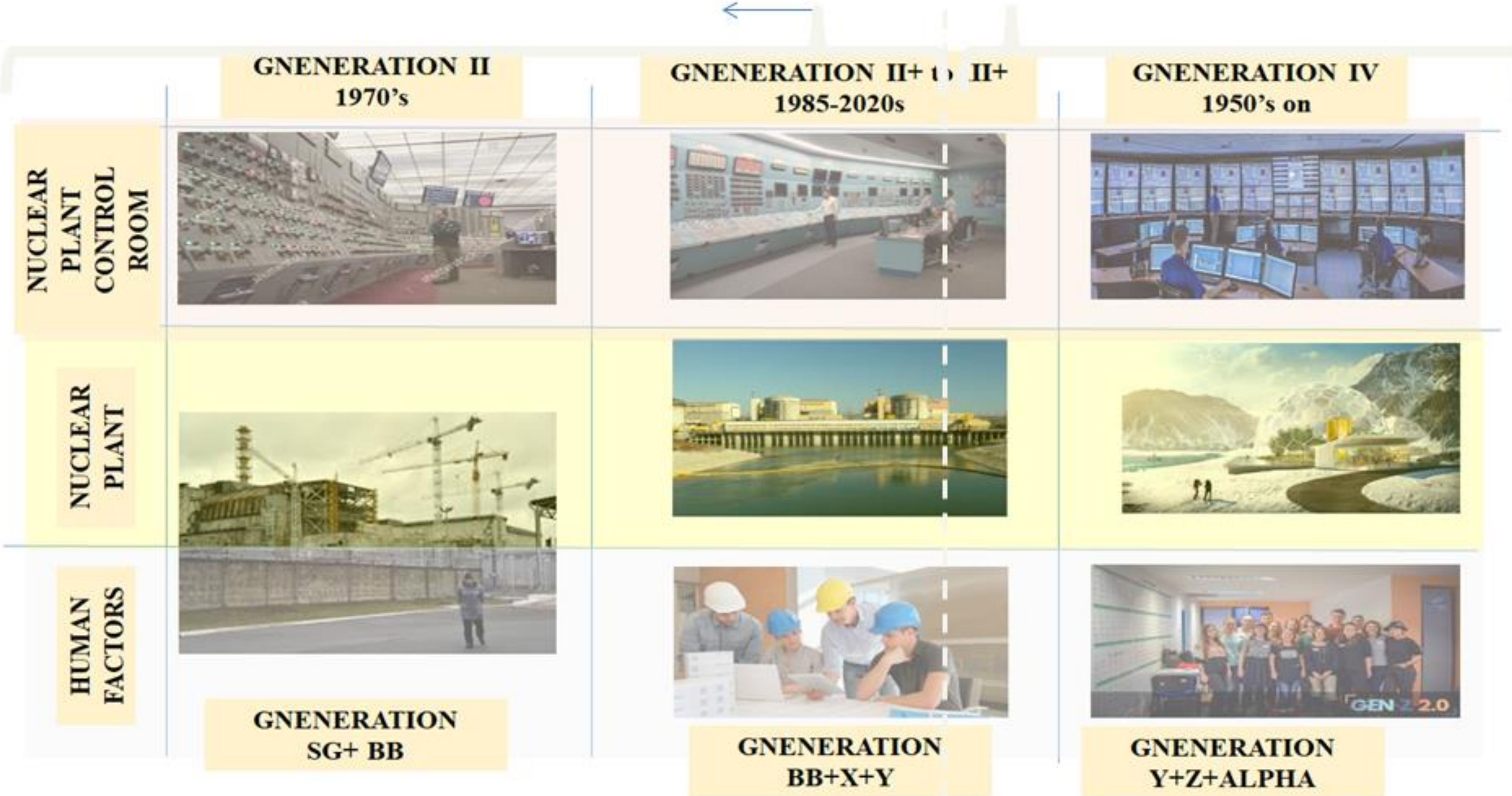

NE in era 3.0 & 4.0
GENERAȚIA II
1970țs
GENERAȚIA II+
1985-2020
III
GENERAȚIA III+ IV
2020 ----
EN PARTEA CONTROL
EN PARTEA CONTROL
EN PARTEA CONTROL
EN PARTEA HARD
EN PARTEA HARD
EN PARTEA HARD
FACTOR UMAN & MANAGEMENT & LEADERSHIP
FACTOR UMAN & MANAGEMENT & LEADERSHIP
FACTOR UMAN & MANAGEMENT & LEADERSHIP
GENERAȚIA
SG BB
GENERAȚIA
BB +X + Y
GENERAȚIA
Y+Z+ALPHA BETA

ERE INDUSTRIALE

ETAPE EN – STIINȚE APLICATE NUCLEARE SI ENERGETICĂ NUCLEARĂ

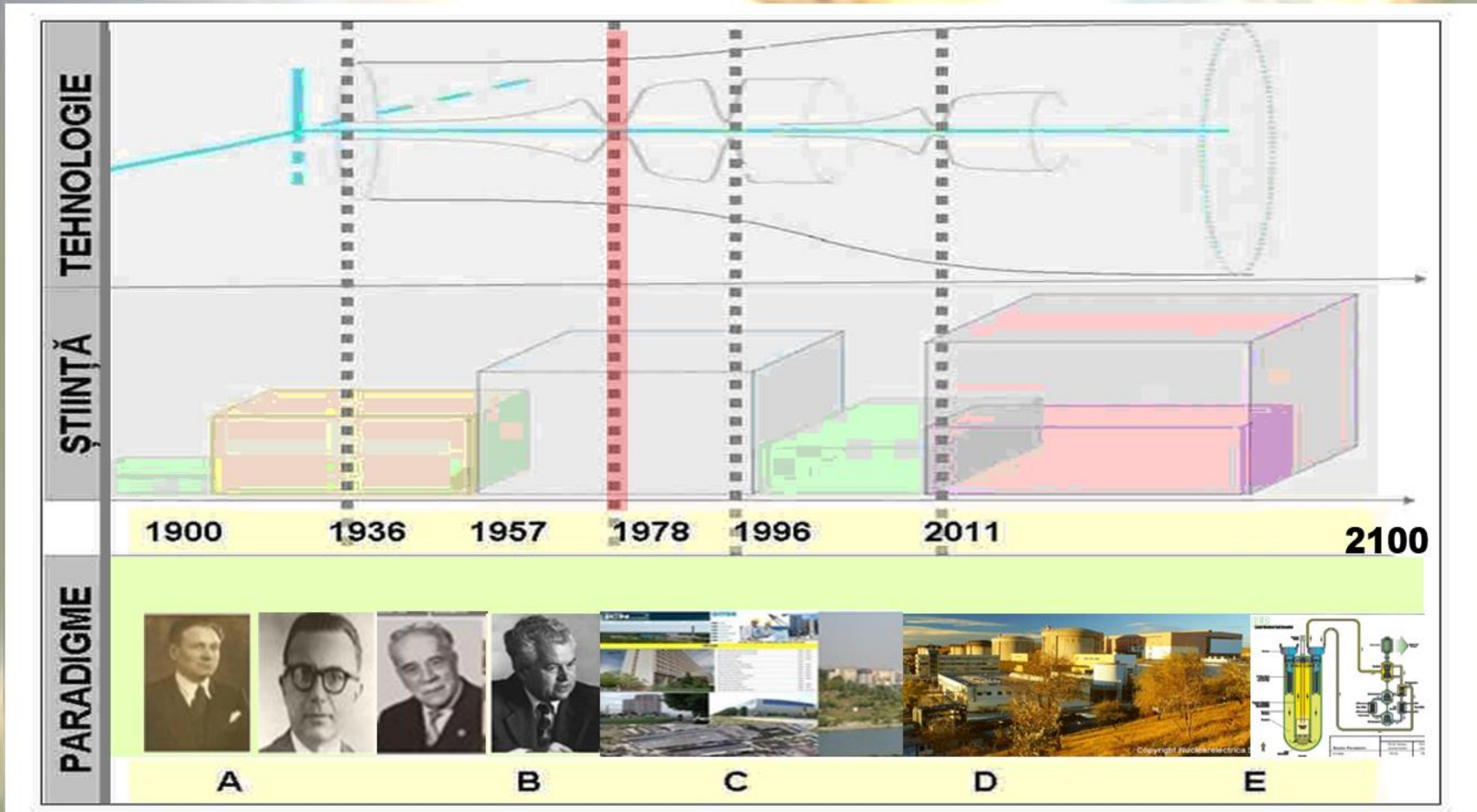


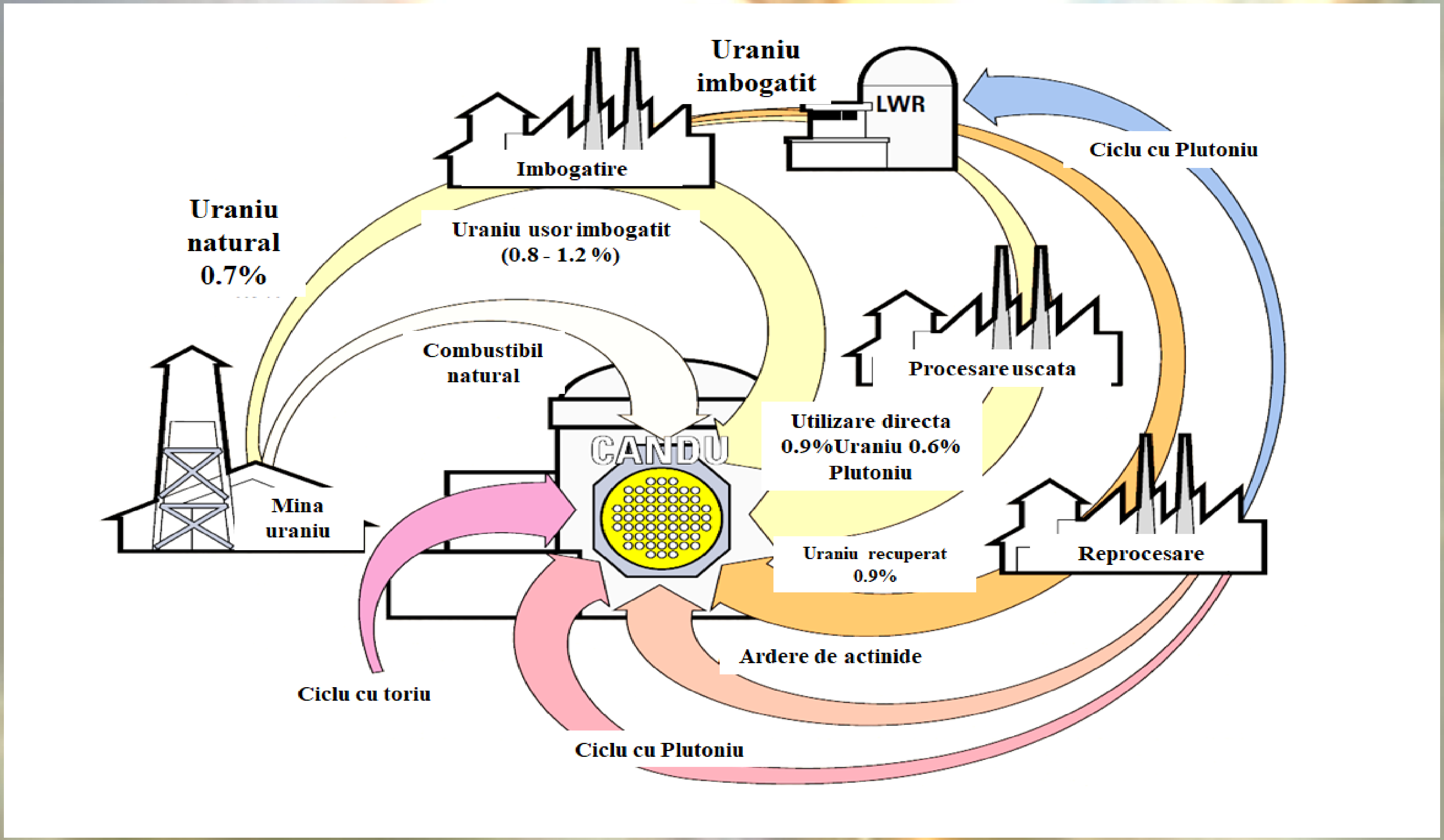
EN in erele 3.0 si 4.0

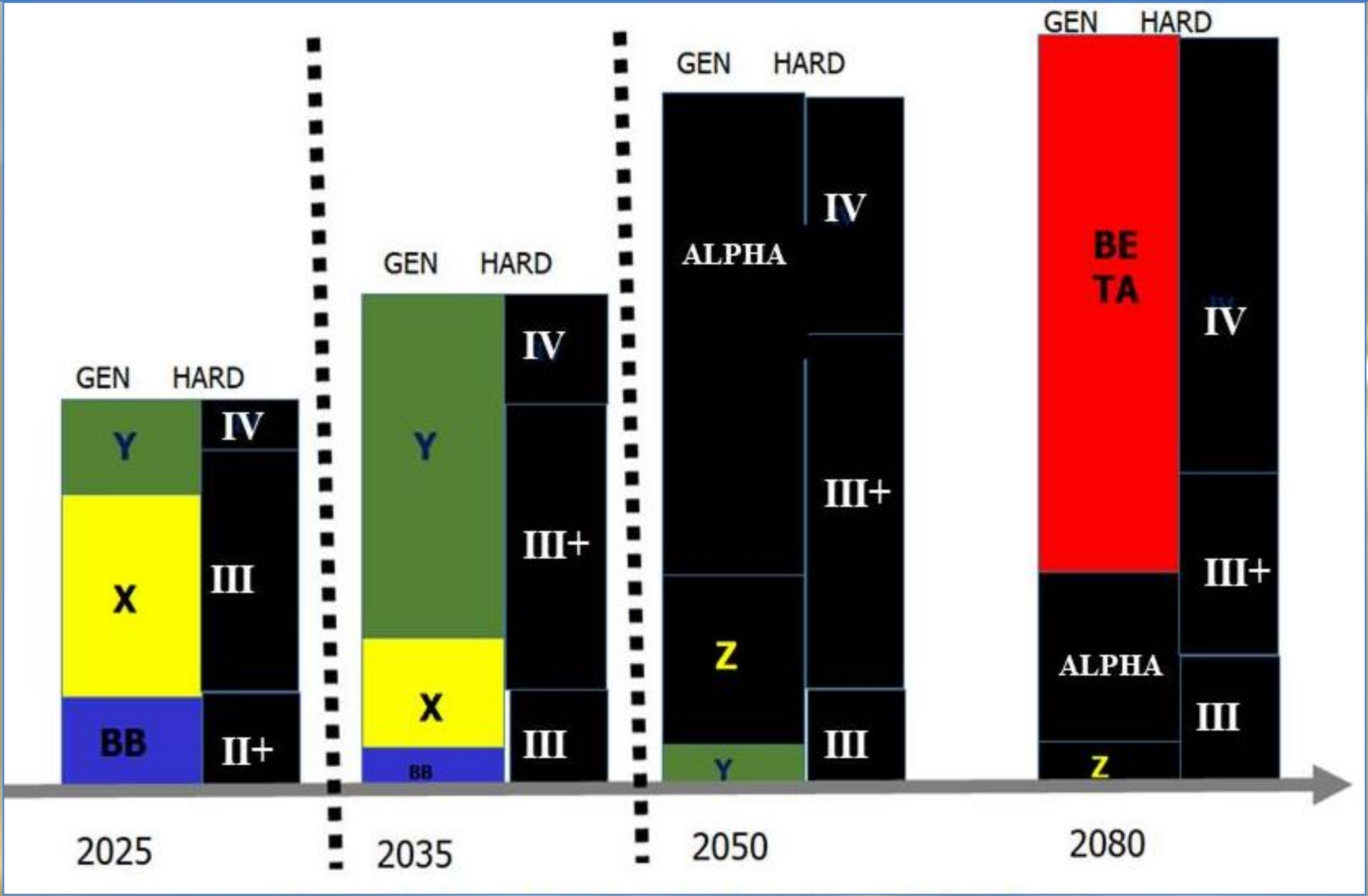


Locul fizicii si energeticii nucleare in Romania intr-un secol si jumatate (2)

Un secol și jumătate de fizică teoretică (A-E) și patru decenii de energetică nucleară (C-E)



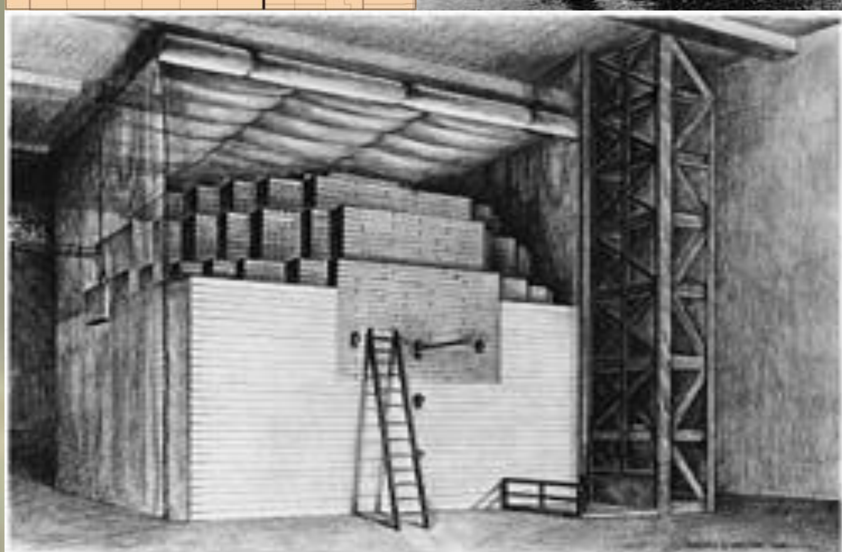

Uraniu imbogatit
LWR
Ciclu cu Plutoniu
Imbogatire
Uraniu natural 0.7%
Uraniu usor imbogatit (0.8 - 1.2 %)
Combustibil natural
Procesare uscata
CANDU
Utilizare directa 0.9%Uraniu 0.6% Plutoniu
Mina uraniu
Reprocesare
Uraniu recuperat 0.9%
Ardere de actinide
Ciclu cu toriu
Ciclu cu Plutoniu


GEN
HARD
Y
IV
X
III
BB
II+
2025
GEN
HARD
IV
Y
III+
X
III
BB
2035
GEN
HARD
ALPHA
IV
III+
Z
Y
III
2050
GEN
HARD
BE
TA
IV
III+
ALPHA
III
Z
2080

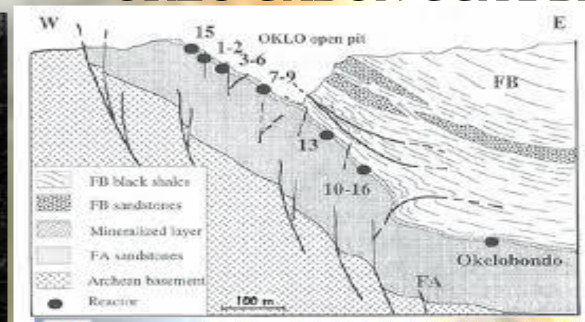
4. Intarirea sectorului nuclear si cresterea contributiei sale

- **i. Consolidarea functionarii pe termen lung a centralelor in functione care functioneaza in regim de baza de sarcina in SEN**
  - **a. Retehnologizarea U1**
  - **b. Punerea in functiune de noi centrale de mare putere (U3/4)**
- **ii. Considerarea energetiicii nucleare pentru a participa la reglarea in SEN prin utilizarea de centrale de puteri mai mici ce asigura acest lucru sub forma reactorilor de fisiune , de tip SMR, etapizat**
  - **a. SMR cu apa**
  - **b. SMR de generatie IV**

CHICAGO PILE 1942-1943

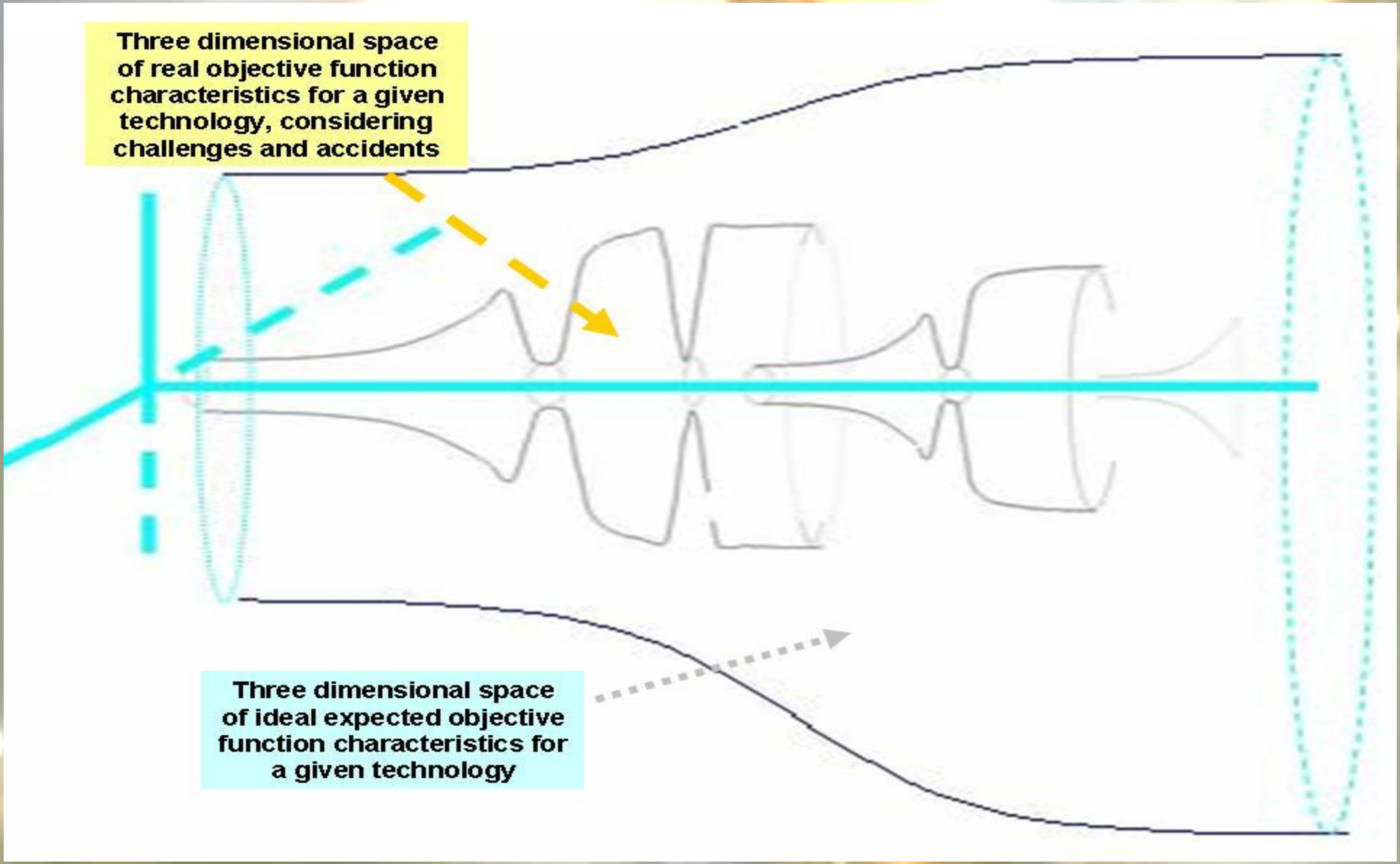


OKLO GABON CCA 2 BLN YEARS AGO

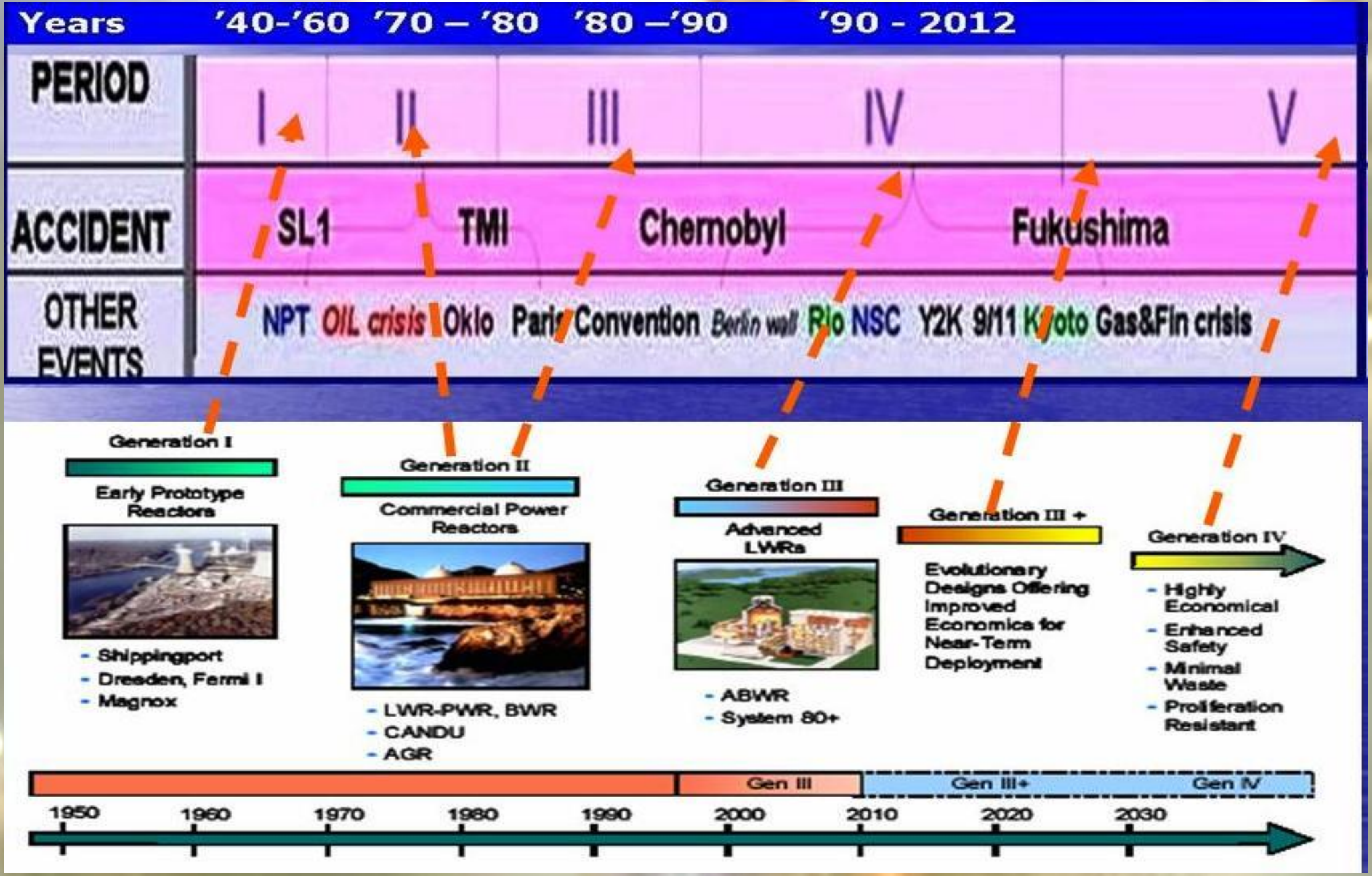


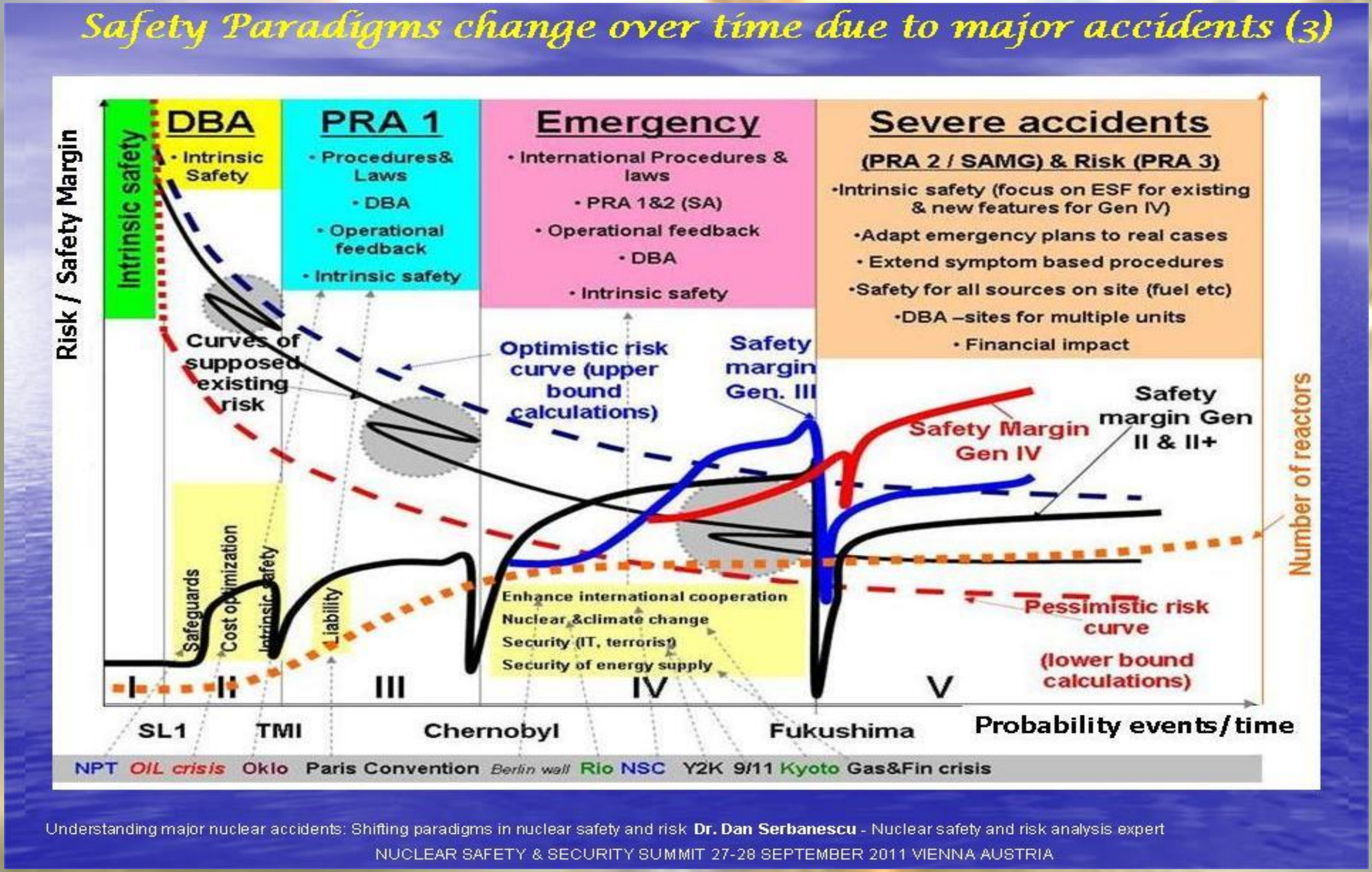
ANNEX 5

INVATAMINTELE DEZVOLTARII STIINTIFICE SI TEHNOLOGICE NUCLEARE

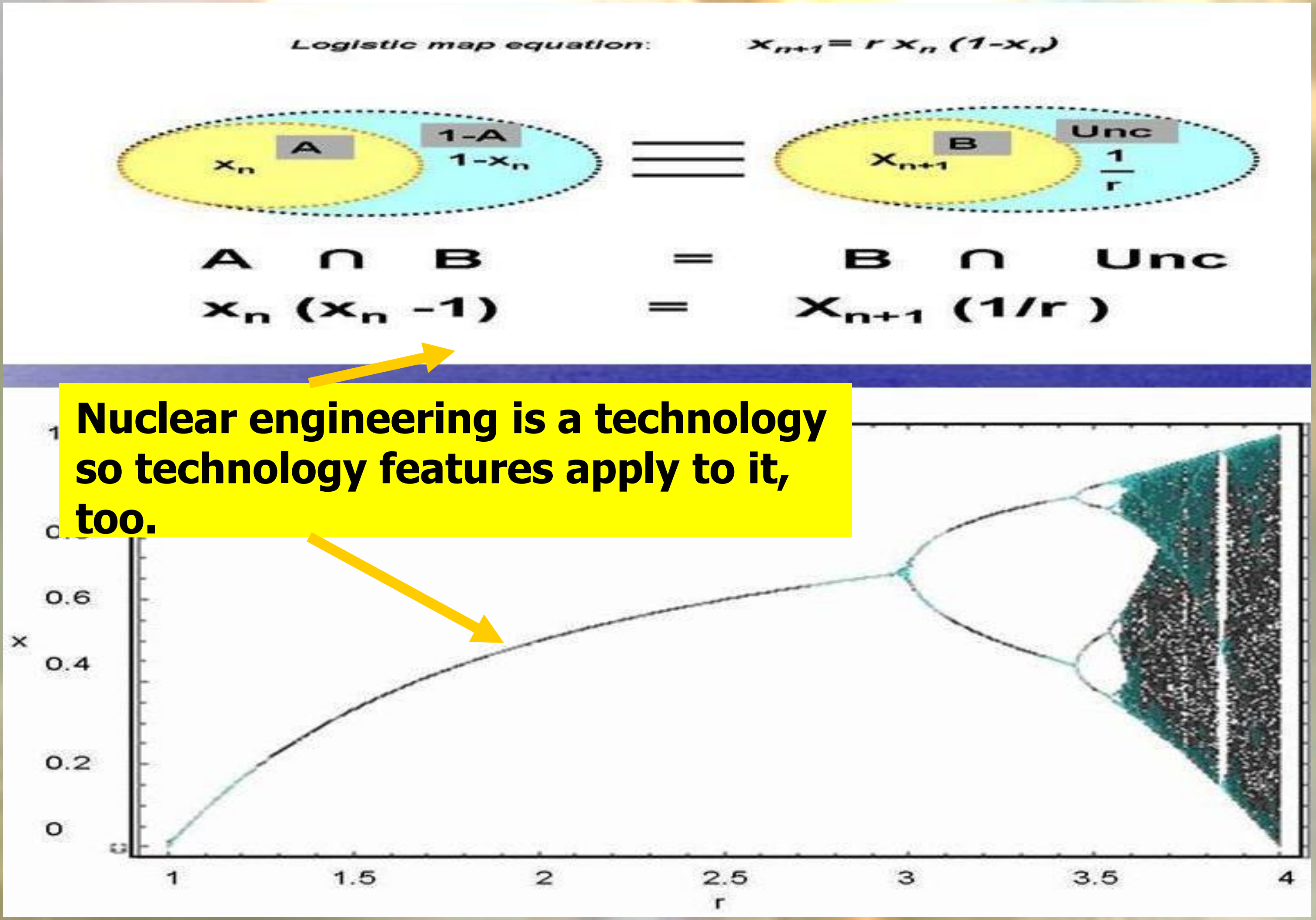

Three dimensional space of real objective function characteristics for a given technology, considering challenges and accidents
Three dimensional space of ideal expected objective function characteristics for a given technology

EN si etapele sale de pana acum




Safety Paradigms change over time due to major accidents (3)
Risk / Safety Margin
Intrinsic safety
DBA
• Intrinsic Safety
PRA 1
• Procedures& Laws
• DBA
• Operational feedback
• Intrinsic safety
Emergency
• International Procedures & laws
• PRA 1&2 (SA)
• Operational feedback
• DBA
• Intrinsic safety
Severe accidents
(PRA 2 / SAMG) & Risk (PRA 3)
•Intrinsic safety (focus on ESF for existing & new features for Gen IV)
•Adapt emergency plans to real cases
• Extend symptom based procedures
•Safety for all sources on site (fuel etc)
•DBA –sites for multiple units
• Financial impact
Curves of supposed existing risk
Optimistic risk curve (upper bound calculations)
Safety margin Gen. III
Safety Margin Gen IV
Safety margin Gen II & II+
Number of reactors
Safeguards
Cost optimization
Intrinsic safety
Liability
Enhance international cooperation
Nuclear &climate change
Security (IT, terrorist)
Security of energy supply
Pessimistic risk curve
(lower bound calculations)
I
II
III
IV
V
SL1
TMI
Chernobyl
Fukushima
Probability events/time
NPT OIL crisis Oklo Paris Convention Berlin wall Rio NSC Y2K 9/11 Kyoto Gas&Fin crisis
Understanding major nuclear accidents: Shifting paradigms in nuclear safety and risk Dr. Dan Serbanescu - Nuclear safety and risk analysis expert
NUCLEAR SAFETY & SECURITY SUMMIT 27-28 SEPTEMBER 2011 VIENNA AUSTRIA

Tehnologiile si viitorul lor



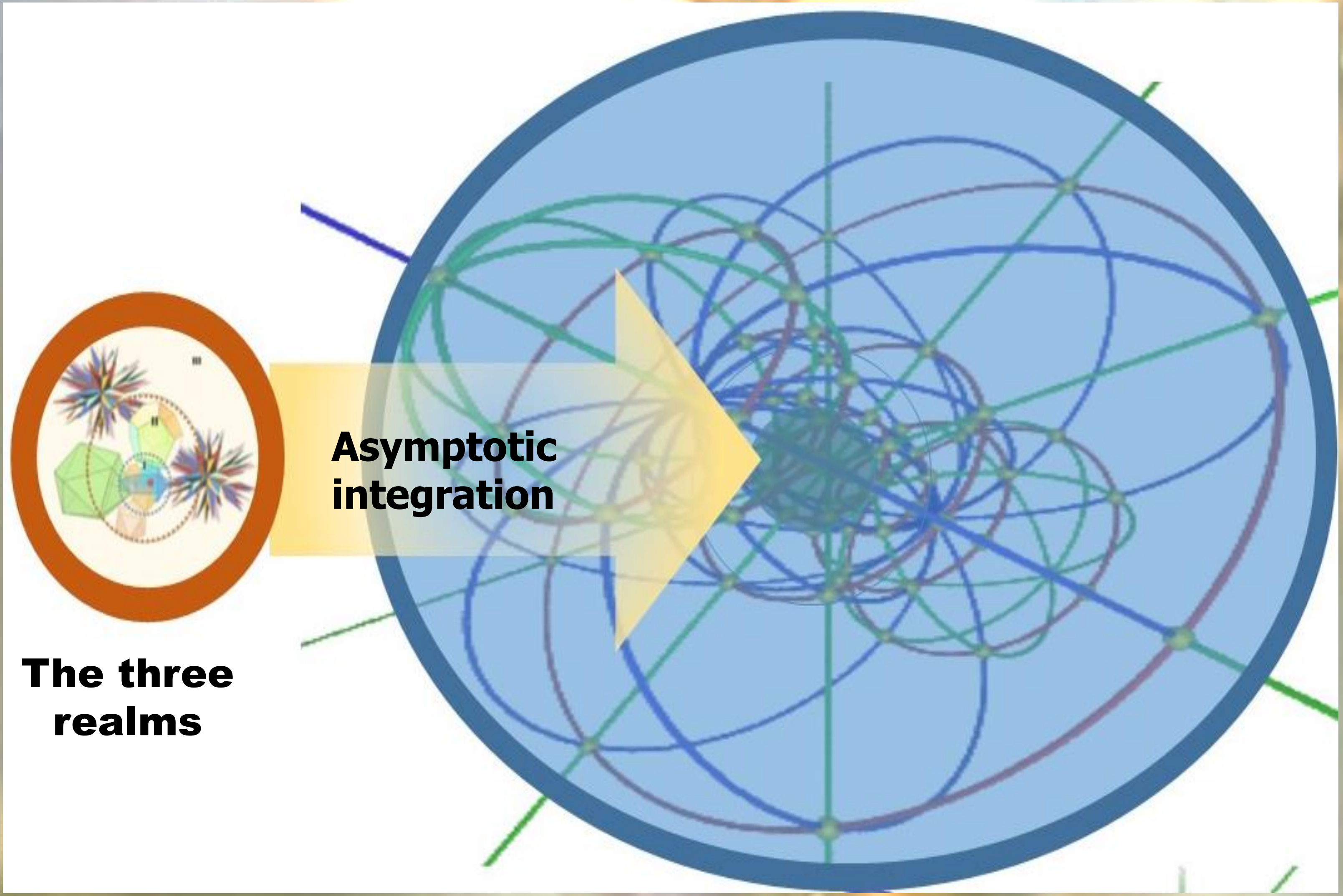
Nuclear engineering is a technology so technology features apply to it, too.

SMR pot indeplini functii complementare

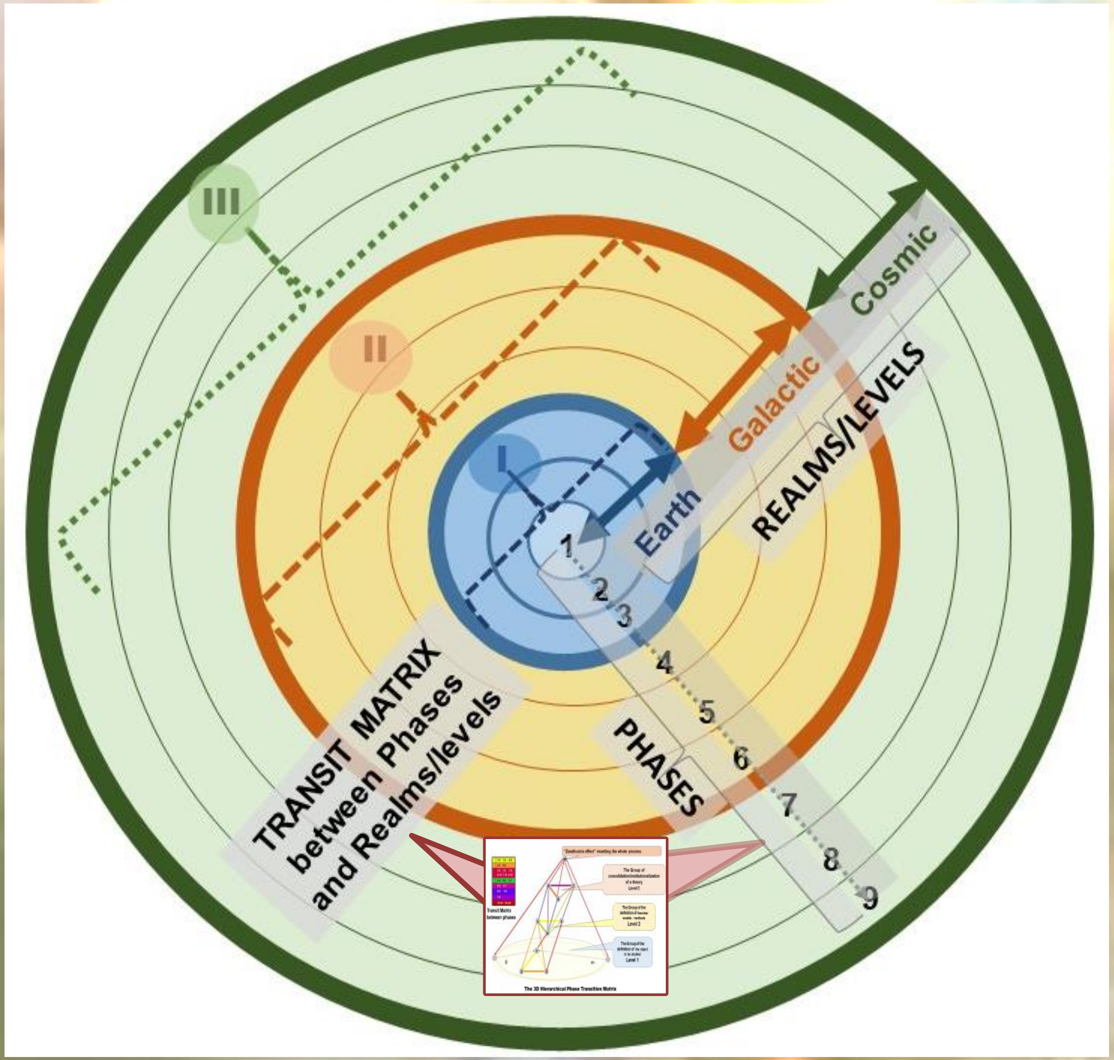
- Centralelor de mare putere in furnizarea de energie in regim de reglaj de frecventa in SEN
  - Pentru asigurarea de energie termica
  - Pentru alte aplicatii (de exemplu fabricarea de hidrogen)
- Pentru functionarea in tandem pe platforme energetice cu surse regenerabile si sisteme de stocare a energiei
- Pot asigura (in variantele cu alti agenti de racire decat apa, ca centrale de generatie IV, cicluri de combustibil mai bine integrate, si micsorarea foarte semnificativa a deseurilor inalt radioactive

SMR pot da solutii la actualele probleme energetice in general si ale celei nucleare mai ales cele nationale in particular, si anume:

1. **Asigura introducerea gradata de innoiri in domeniul nuclear. Plecand de la elemente de proiect si fabricatie/exploatare recunoscute si verificate, SMR cu apa introduc elemente suplimentare de protectie pasiva la accidente foarte severe si asigura o siguranta crescuta centralelor. Rezista mult mai bine, practic nu sunt afectate de accidente foarte severe si de hazarduri externe (cutremure, caderi de avioane etc)**
2. **Prin aspectul modular si constructia fiecarui modul pot asigura o participare flexibile la furnizarea de energeie electrica in SEN si de asemenea asigura aplicatii de mar interes ca furnizarea de energie termica, fabricatia hidrogenului**
3. **Asigura un volum mult redus de deseuri radioactive, mai ales cele inalt radioactive**
4. **Sunt mult mai usor de construit, fazele importante avand loc in uzinele de fabricatie, au posibilitatea standardizarii si utilizeaza tehnologii deja omologate.**
5. **Planul de urgenta este mult mai simplu si centrala are un nivel de risk foarte redus**
6. **Are o durata si un cost de instalare si PIF mult reduse fata de cele de putere mare.**
7. **Pot utiliza amplasamente dezafectate de obiective industriale si/sau centrale termice dezafectate.**
8. **Pot face parte din platforme flexibile de energie cu surse regenerabile.**



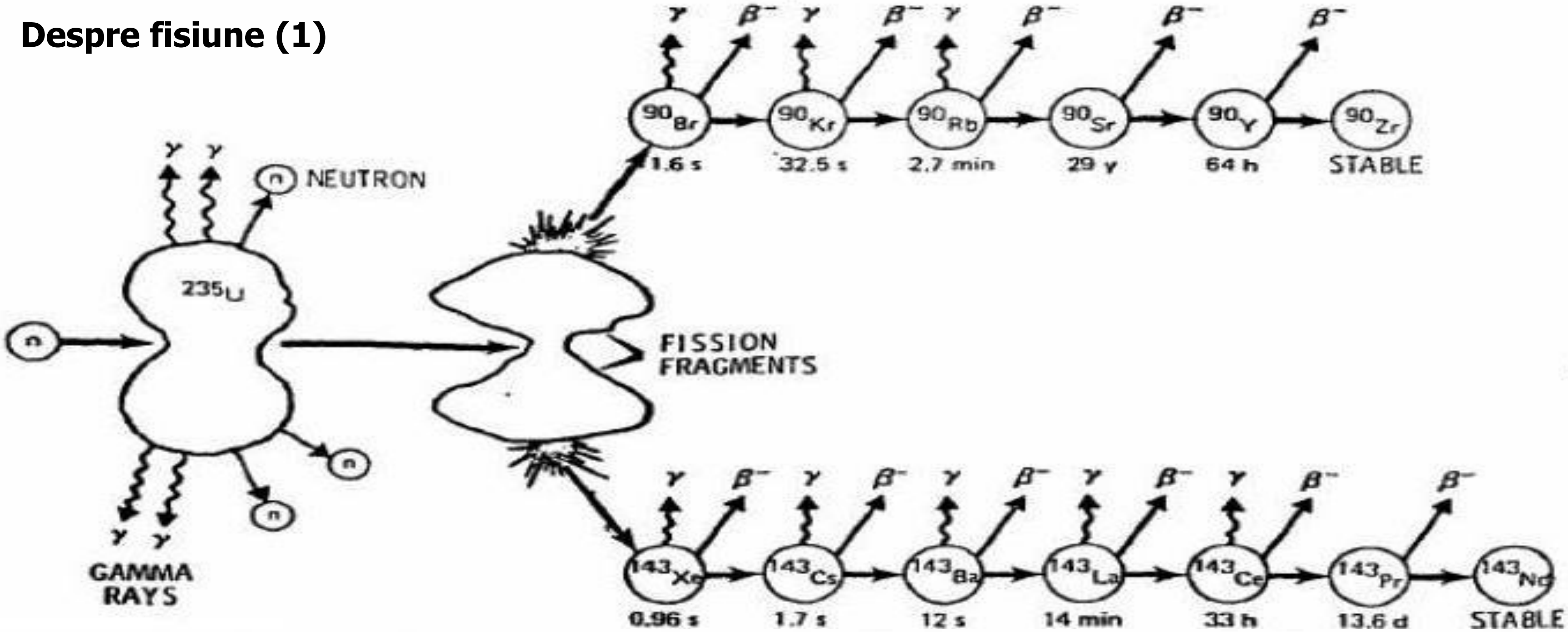
The n sphere of cosmic realm


III
II
I
Cosmic
Galactic
Earth
REALMS/LEVELS
1
2
3
4
5
6
7
8
9
PHASES
TRANSIT MATRIX between Phases and Realms/levels

ANNEX 6

ASPECTE SPECIFICE DE PROVOCARI IN FIZICA NUCLEARA SI MATEMATICA

Despre fisiune (1)



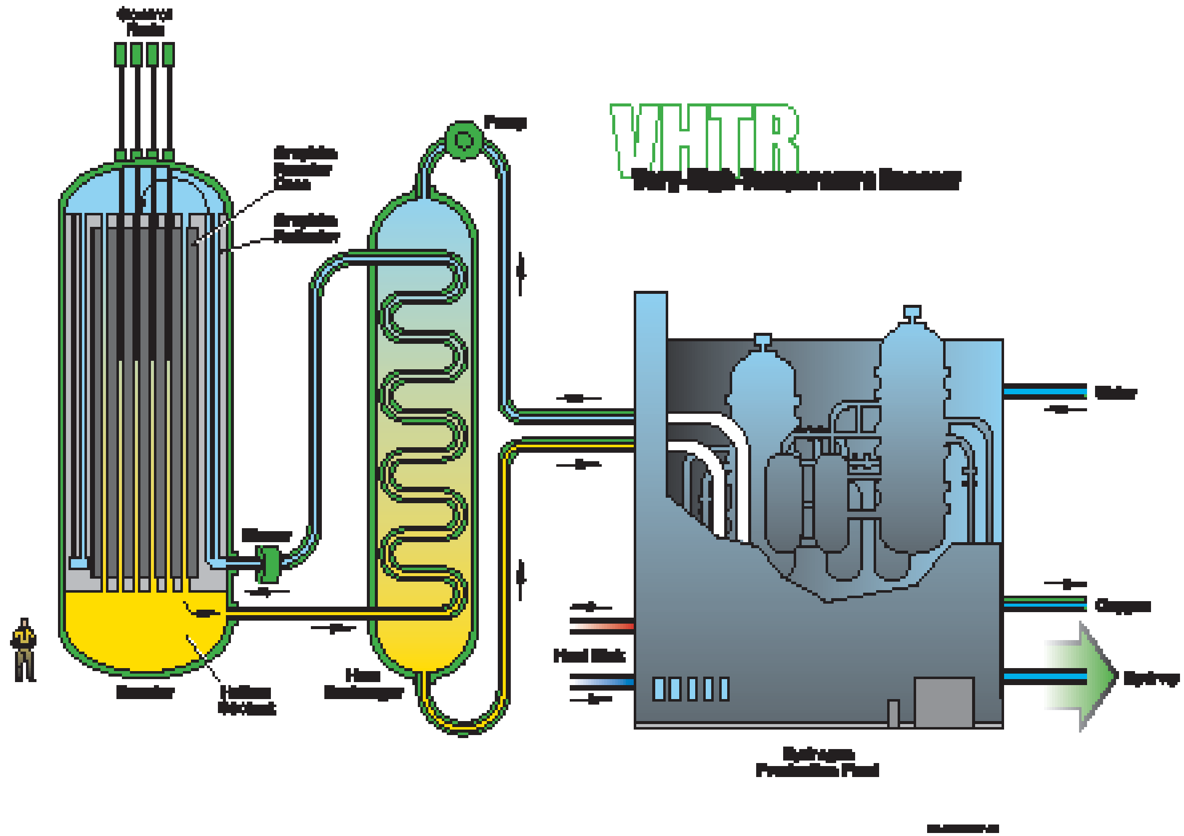
Energy source	Fission energy (MeV)	Heat produced MeV	Heat produced % of tot:
Fission fragments	168	168	84
Neutrons	5	5	2.5
Prompt gamma rays	7	7	3.5
Delayed radiations			
Beta particles†	20	8	4
Gamma rays	7	7	3.5
Radiative capture gammas‡	—	5	2.5
Total	207	200	100

	DOMAIN	AREA	SHORT DESCRIPTION
	General physics/quantum physics	Entropy (arrow of time)	Why did the universe have such low entropy in the past, resulting in the distinction between past and future and the second law of thermodynamics?[2] Why are CP violations observed in certain weak force decays, but not elsewhere? Are CP violations somehow a product of the Second Law of Thermodynamics, or are they a separate arrow of time? Are there exceptions to the principle of causality? Is there a single possible past? Is the present moment physically distinct from the past and future or is it merely an emergent property of consciousness? Why does time have a direction? What links the quantum arrow of time to the thermodynamic arrow?
	General physics/quantum physics	Interpretation of quantum mechanics	How does the quantum description of reality, which includes elements such as the superposition of states and wavefunction collapse or quantum decoherence, give rise to the reality we perceive? Another way of stating this question regards the measurement problem: What constitutes a "measurement" which causes the wave function to collapse into a definite state? Unlike classical physical processes, some quantum mechanical processes (such as quantum teleportation arising from quantum entanglement) cannot be simultaneously "local", "causal", and "real", but it is not obvious which of these properties must be sacrificed or if an attempt to describe quantum mechanical processes in these senses is a category error such that a proper understanding of quantum mechanics would render the question meaningless.
	General physics/quantum physics	Grand Unification Theory ("Theory of everything")	Is there a theory which explains the values of all fundamental physical constants? Is the theory string theory? Is there a theory which explains why the gauge groups of the standard model are as they are, why observed spacetime has 3 spatial dimensions and 1 temporal dimension, and why all laws of physics are as they are? Do "fundamental physical constants" vary over time? Are any of the particles in the standard model of particle physics actually composite particles too tightly bound to observe as such at current experimental energies? Are there fundamental particles that have not yet been observed, and, if so, which ones are they and what are their properties? Are there unobserved fundamental forces implied by a theory that explains other unsolved problems in physics?
	General physics/quantum physics	Yang–Mills theory	Given an arbitrary compact gauge group, does a non-trivial quantum Yang–Mills theory with a finite mass gap exist? This problem is also listed as one of the Millennium Prize Problems in mathematics.
	General physics/quantum physics	Physical information	Are there physical phenomena, such as wave function collapse or black holes, which irrevocably destroy information about their prior states? How is quantum information stored as a state of a quantum system?
	General physics/quantum physics	Dimensionless physical constant	At the present time, the values of the dimensionless physical constants cannot be calculated; they are determined only by physical measurement. What is the minimum number of dimensionless physical constants from which all other dimensionless physical constants can be derived? Are dimensionful physical constants necessary at all?
	General physics/quantum physics	Fine-tuned Universe	What explains why the fundamental physical constants are set in the narrow range that is necessary to support carbon-based life?

CHALLENGES IN PHYSICS (2)

	Cosmology and general relativity	Cosmic inflation	Is the theory of cosmic inflation correct, and, if so, what are the details of this epoch? What is the hypothetical inflaton field giving rise to inflation? If inflation happened at one point, is it self-sustaining through inflation of quantum-mechanical fluctuations, and thus ongoing in some extremely distant place?
	Cosmology and general relativity	Horizon problem	Why is the distant universe so homogeneous when the Big Bang theory seems to predict larger measurable anisotropies of the night sky than those observed? Cosmological inflation is generally accepted as the solution, but are other possible explanations such as a variable speed of light more appropriate?
	Cosmology and general relativity	Future of the universe	Is the universe heading towards a Big Freeze, a Big Rip, a Big Crunch, or a Big Bounce? Or is it part of an infinitely recurring cyclic model?
	Cosmology and general relativity	Baryon asymmetry	Why is there far more matter than antimatter in the observable universe?
	Cosmology and general relativity	Cosmological constant problem	Why does the zero-point energy of the vacuum not cause a large cosmological constant? What cancels it out?
	Cosmology and general relativity	Dark matter	What is the identity of dark matter? Is it a particle? Is it the lightest superpartner (LSP)? Do the phenomena attributed to dark matter point not to some form of matter but actually to an extension of gravity?
	Cosmology and general relativity	Dark energy	What is the cause of the observed accelerated expansion (de Sitter phase) of the Universe? Why is the energy density of the dark energy component of the same magnitude as the density of matter at present when the two evolve quite differently over time; could it be simply that we are observing at exactly the right time? Is dark energy a pure cosmological constant or are models of quintessence such as phantom energy applicable?
	Cosmology and general relativity	Dark flow	Is a non-spherically symmetric gravitational pull from outside the observable Universe responsible for some of the observed motion of large objects such as galactic clusters in the universe?
	Cosmology and general relativity	Ecliptic alignment of CMB anisotropy	Some large features of the microwave sky at distances of over 13 billion light years appear to be aligned with both the motion and orientation of the solar system. Is this due to systematic errors in processing, contamination of results by local effects, or an unexplained violation of the Copernican principle?
	Cosmology and general relativity	Shape of the Universe	What is the 3-manifold of comoving space, i.e. of a comoving spatial section of the Universe, informally called the "shape" of the Universe? Neither the curvature nor the topology is presently known, though the curvature is known to be "close" to zero on observable scales. The cosmic inflation hypothesis suggests that the shape of the Universe may be unmeasurable, but, since 2003, Jean-Pierre Luminet, et al., and other groups have suggested that the shape of the Universe may be the Poincaré dodecahedral space. Is the shape unmeasurable; the Poincaré space; or another 3-manifold?

Very-High-Temperature Reactor



Reactor Parameters	Reference Value
Reactor power	600 MWth
Coolant inlet/outlet temperature	640/1000°C
Core inlet/outlet pressure	Dependent on process
Helium mass flow rate	320 kg/s
Average power density	6–10 MWth/m^3
Reference fuel compound	ZrC-coated particles in blocks, pins or pebbles
Net plant efficiency	>50%

ANNEX 7

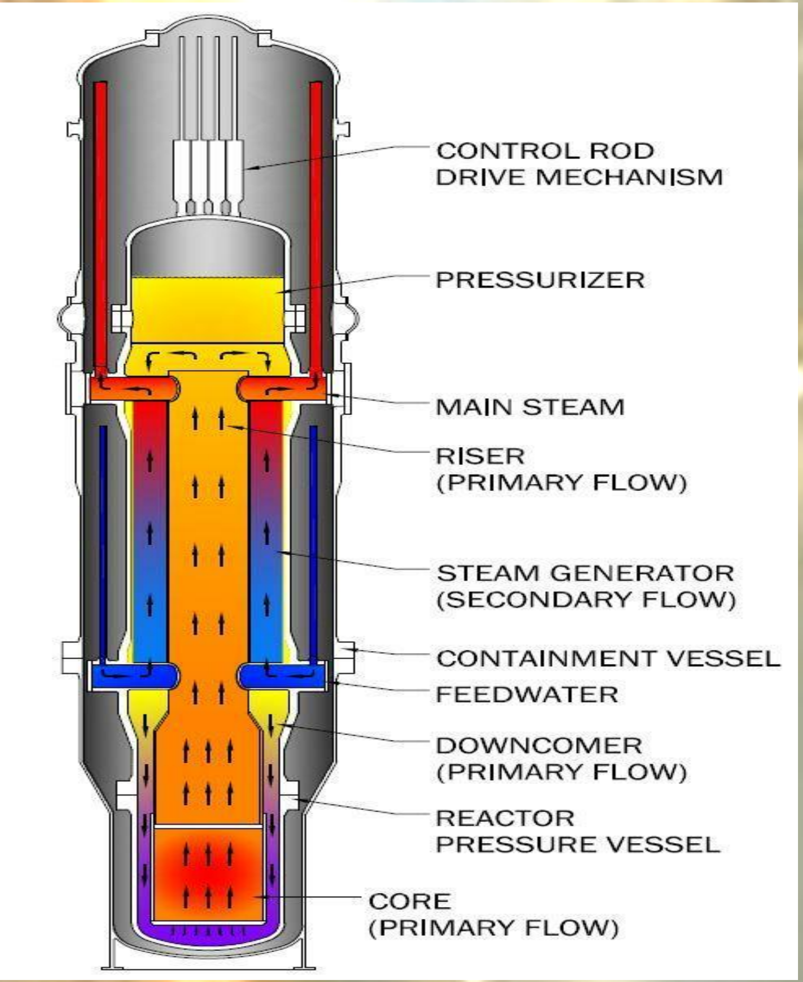
Unele detalii NP in prezentari publice ale NUSCALE

Main NUSCALE design features

- Uses proven LWR components in a simpler and more innovative manner
- It complements the experience of proven solutions with more tests and models using advanced methods
- It assures a good down scaling of existing high power NPP solutions, without negative impact on initial advantages of those solutions,
- Provides resilience on Fukushima dominating accident features related to the protection against prolonged SBO, without additional water, power, or operator action

Source: NRC White Paper, D. Dube; basis for discussion at 2/18/09 public meeting on implementation of risk matrices for new nuclear reactors

- Factory built nuclear steam supply system:
- Primary system and containment is prefabricated and shipped by rail, truck or barge
- Integral design with natural circulation cooling:
- Eliminates major accident scenarios
- Eliminates many pumps, pipes, valves
- Immersed in large ultimate heat sink
- Simplifies and enhances safety case
- Built on proven technology
- Innovation is in the design and engineering
- Constructed below grade
- Enhances security and safet

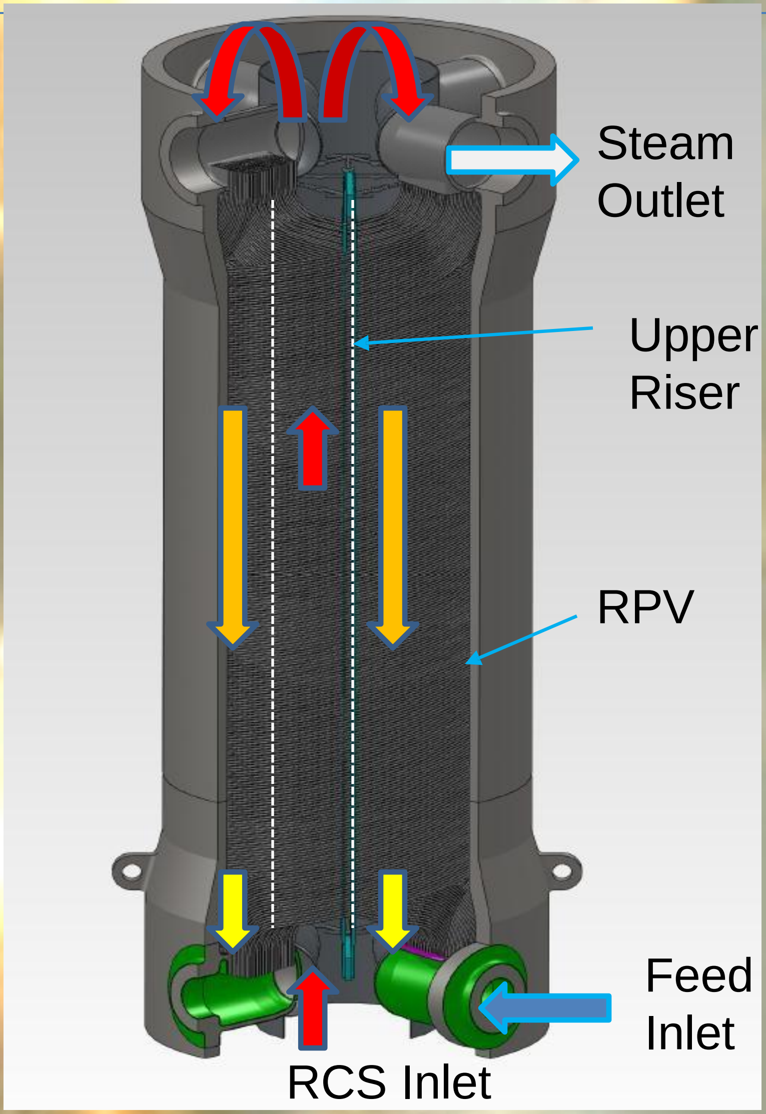


Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Integrated Helical Coil SG

Steam Generator is fully integrated within the reactor pressure vessel (RPV)

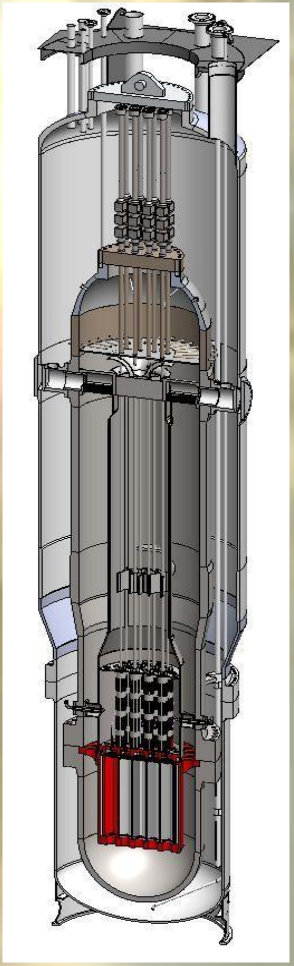
- **Contained in annulus between the upper riser and the RPV shell**
- **Feed flow enters the feed plenums, flows upward through the inside of the tubes and is discharged via the steam headers**
- **Reactor coolant flows upward through the upper riser, is turned by the pressurizer baffle plate, and flows down through the helical bundle**



8 NP-PM-MMYY-XXXX-NP Rev. X

Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

New Containment Paradigm - Compact, High-Pressure

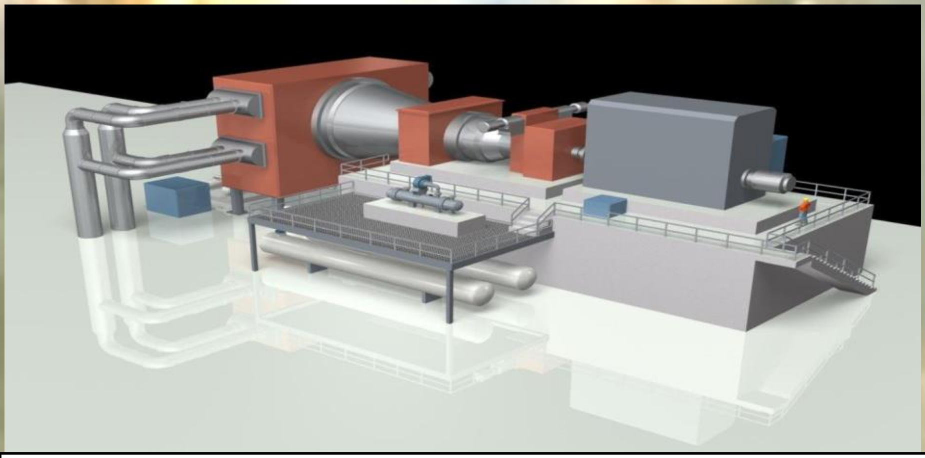


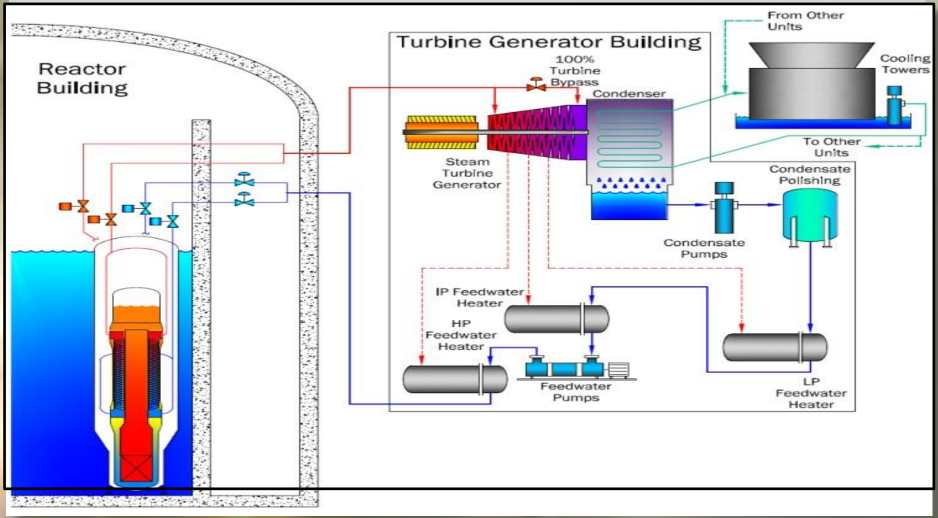
- **Equilibrium pressure between reactor and containment following any LOCA is always below containment design pressure**
  - **Insulating Vacuum**
  - **Significantly reduces convection heat transfer during normal operation**
  - **No insulation on reactor vessel -- eliminates sump screen**
  - **blockage issue (GSI-191)**
  - **Improves steam condensation by eliminating air**
  - **Prevents combustible hydrogen mixture in the unlikely event of a severe accident (i.e., little or no oxygen)**
  - **Eliminates corrosion and humidity problems inside containment**
- **Immersion in reactor pool provides assured access to ultimate heat sink for long-term cooling**

Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Independent Turbine/Generators

- Skid mounted
- Controlled fabrication
- Easily transported to site
- Fast onsite installation
- Off-the-shelf models currently available
- Air-cooled generator
- Adaptable to water or air-cooled condenser



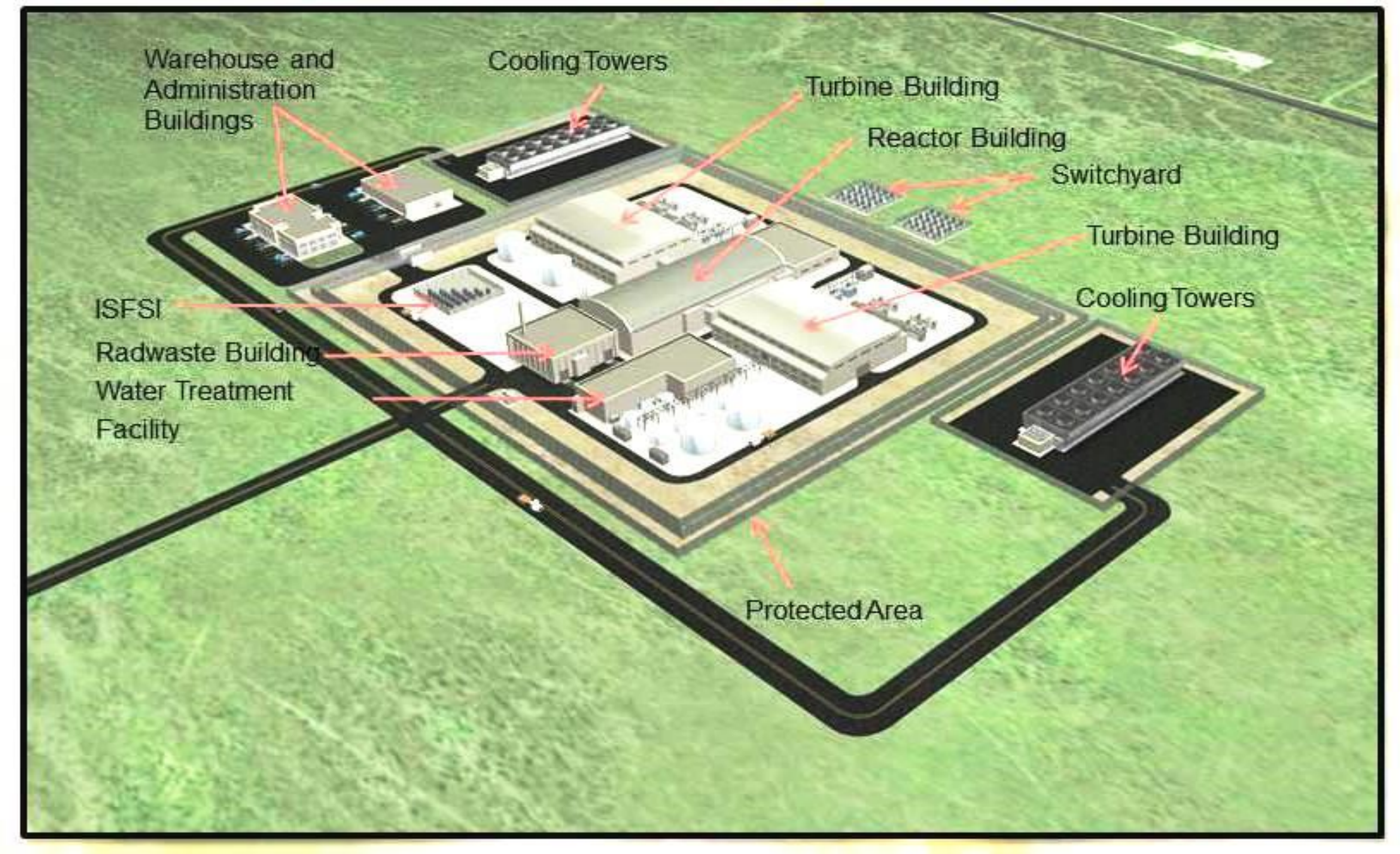


Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Power Module Parameters

Reactor Core	
• Thermal Power Rating	160 MWt
• Operating Pressure	8.72 MPa (1850 psia)
▪ Fuel	UO_2 (< 4.95% enrichment)
▪ Refueling Intervals	24-48 months
▪ Dimensions	19.2 meters x 2.8 meters (Height x Diameter)
▪ Weight	264 tonnes
Containment	
• Dimensions	25.0 meters x 4.6 meters (Height x Diameter)
• Weight	303 tonnes
Power Generation Unit	
• Number of Reactors	One
• Electrical Output	> 47.5 MWe (gross)
• Steam Generator Number	Two independent tube bundles
• Steam Generator Type	Vertical helical tube
• Steam Cycle	Superheated
• Turbine Throttle Conditions	3.1 MPa (450 psia)
• Steam Flow	71.3 kg/s (565,723 lb/hr)
• Feedwater Temperature	149º C (300º F)

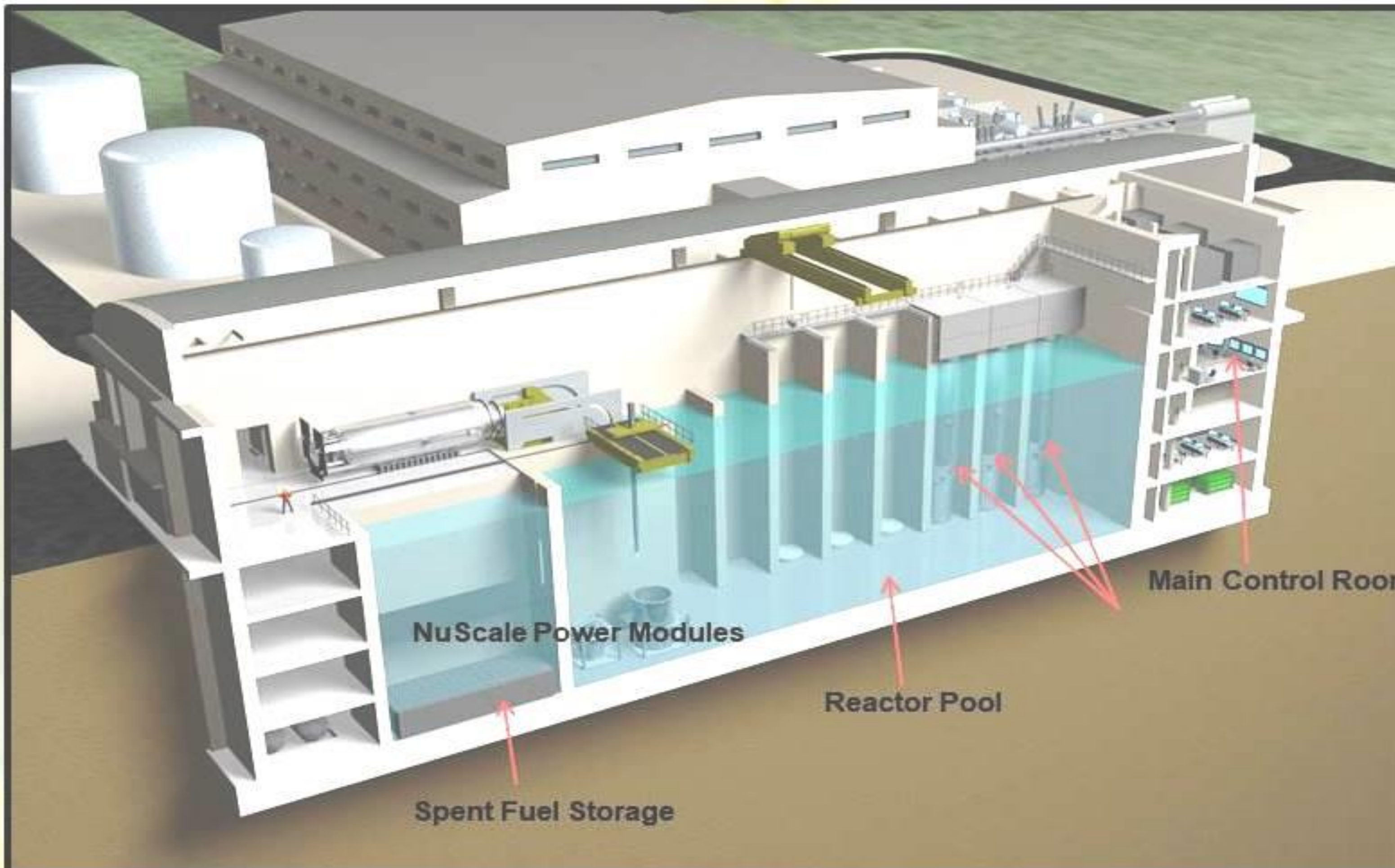
Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary



Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Video 3

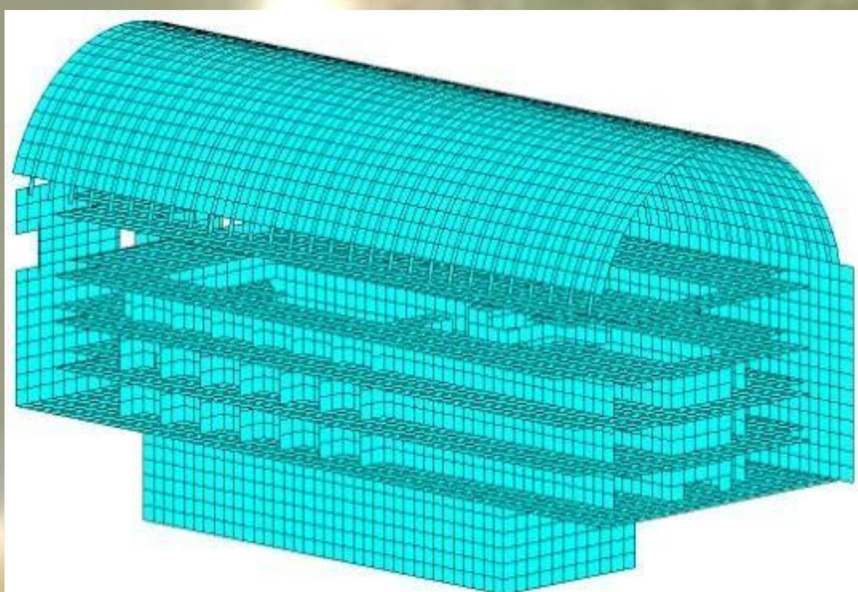
Reactor Building

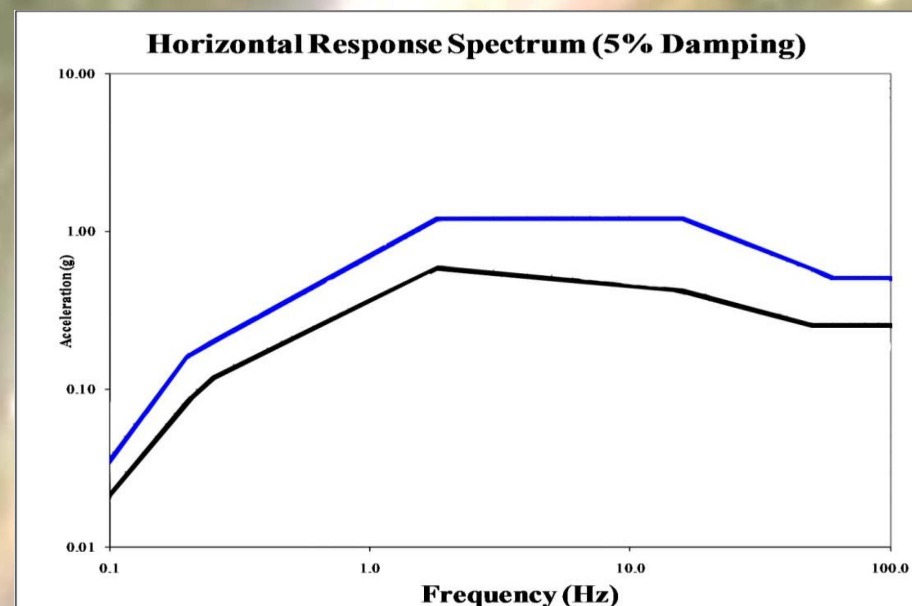


Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Robust Reactor Building Design

- Robust Seismic Spectrum Bounds most of USA sites (0.5 g ZPA)
    - Structure composed almost entirely out of concrete, with well arranged shear walls and diaphragms which provides for high rigidity.
    - Significant portion of the structure located below grade.
- Meets aircraft Impact criteria





Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Basic Plant Parameters

Site Plot Plan	
Protected Area	42 acres
Construction Area (includes protected area)	520 acres
Water Consumption During Operations	
Cooling Water Consumption	36 m^3/minute
Potable Water Consumption	34 m^3/day
Construction Workforce	
Craft Labor (peak)	600
Staff (peak) (supervisory, field engineers, QA, management, etc)	400

Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Passively Safe Reactor Modules

Natural Convection for Cooling

- Inherently safe, gravity-driven natural circulation of water over the fuel
- No pumps, no need for emergency generators

Seismically Robust

- Containment is submerged in a pool of water below ground in an robust building
- Reactor pool attenuates ground motion and dissipates energy

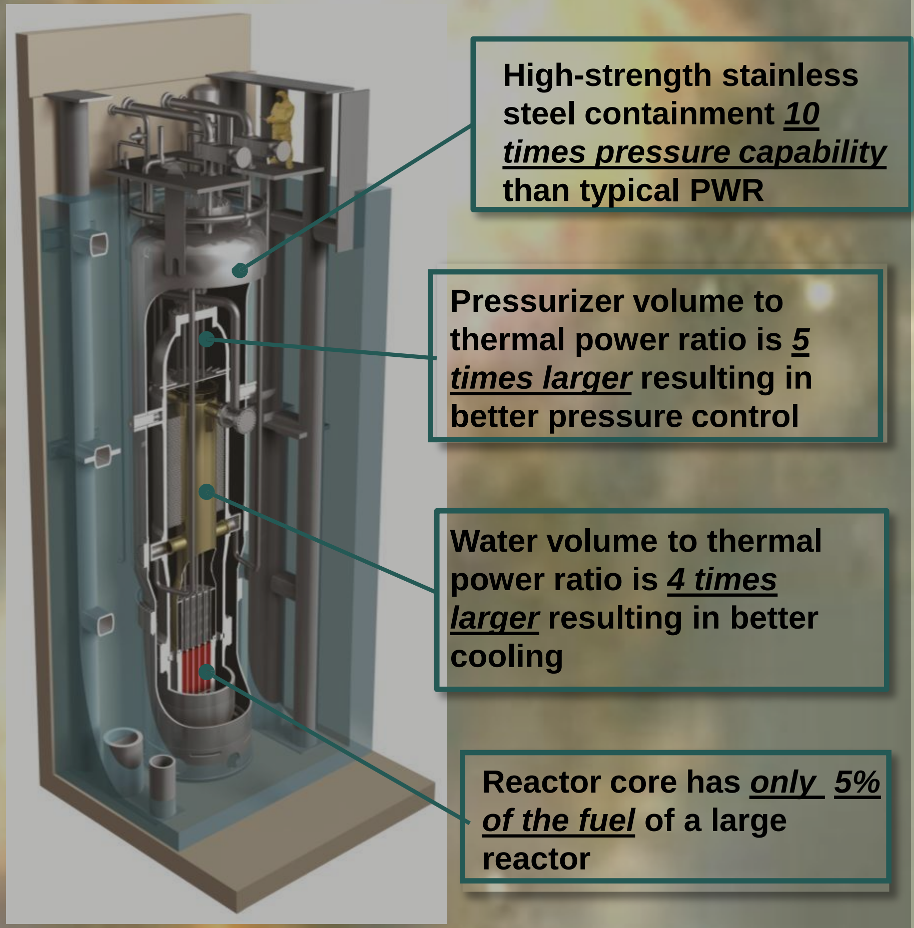
Simple and Small

- Reactor is 1/20th the size of large reactors
- Integrated reactor design, no large-break loss-of-coolant accidents

Defense-in-Depth

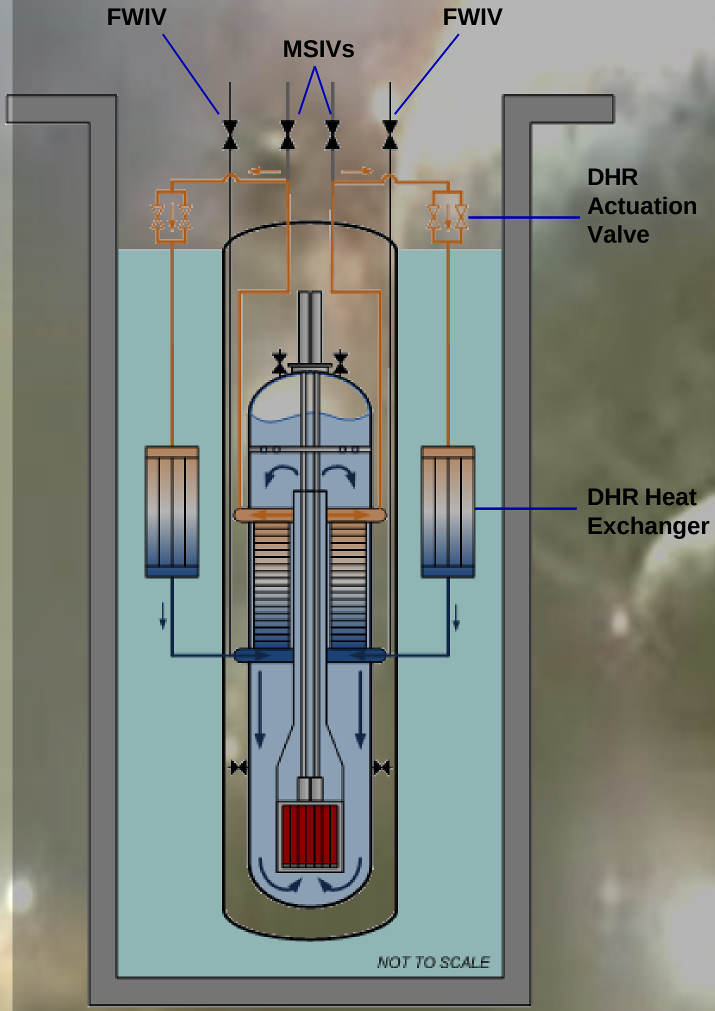
- Multiple additional barriers to protect against the release of radiation to the environment

Reactor Module



Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Decay Heat Removal System



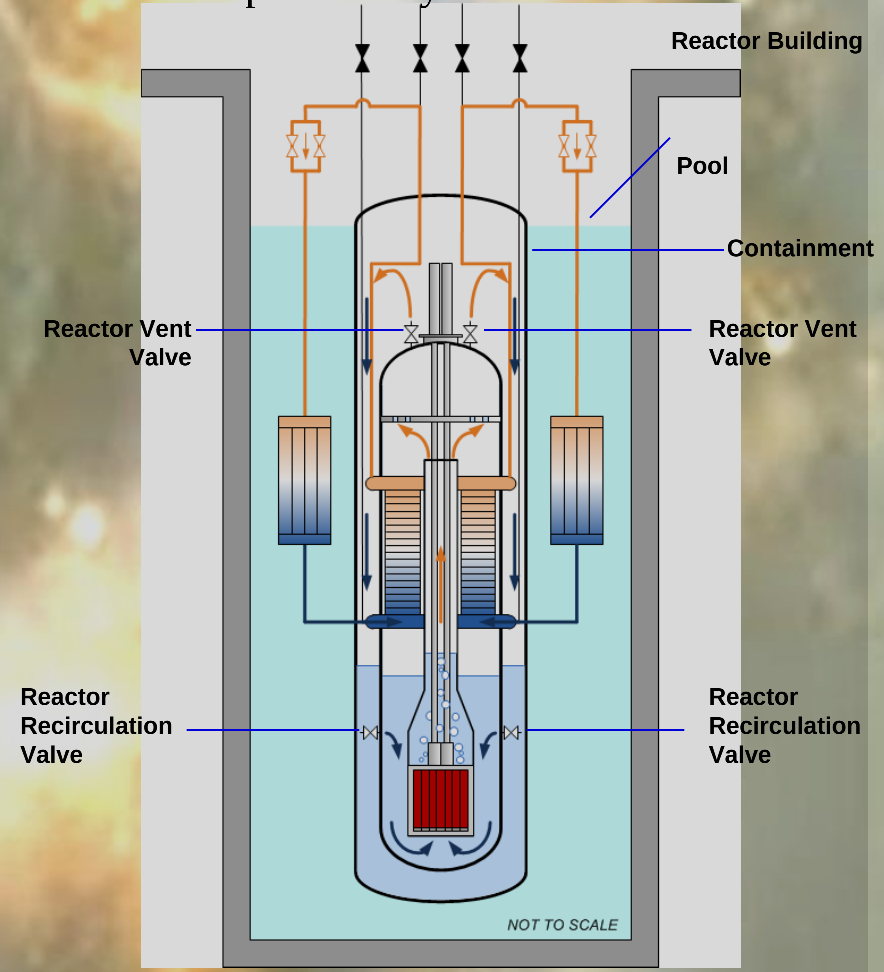
- Two passive, independent single-failure-proof trains
- Closed loop system
- Two-phase natural circulation operation
- DHRS heat exchangers mounted directly on exterior of containment vessel--nominally full of water
- Supplies the coolant inventory
- Natural circulation of primary coolant is maintained
- Pool provides a 3 day cooling supply for decay heat removal

Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Emergency Core Cooling System

Provides a means of removing core decay heat and limits containment pressure by:

- Steam condensation
- Convective heat transfer
  - Heat conduction
  - Sump recirculation
- Reactor vessel steam is vented through the Reactor Vent Valves (flow limiter)
- Steam condenses on containment
- Condensate collects in lower containment
- Reactor Recirculation Valves open to provide recirculation path through the core
- Provides >30 day cooling followed by unlimited period of air cooling.



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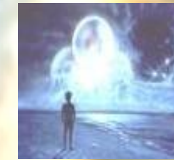
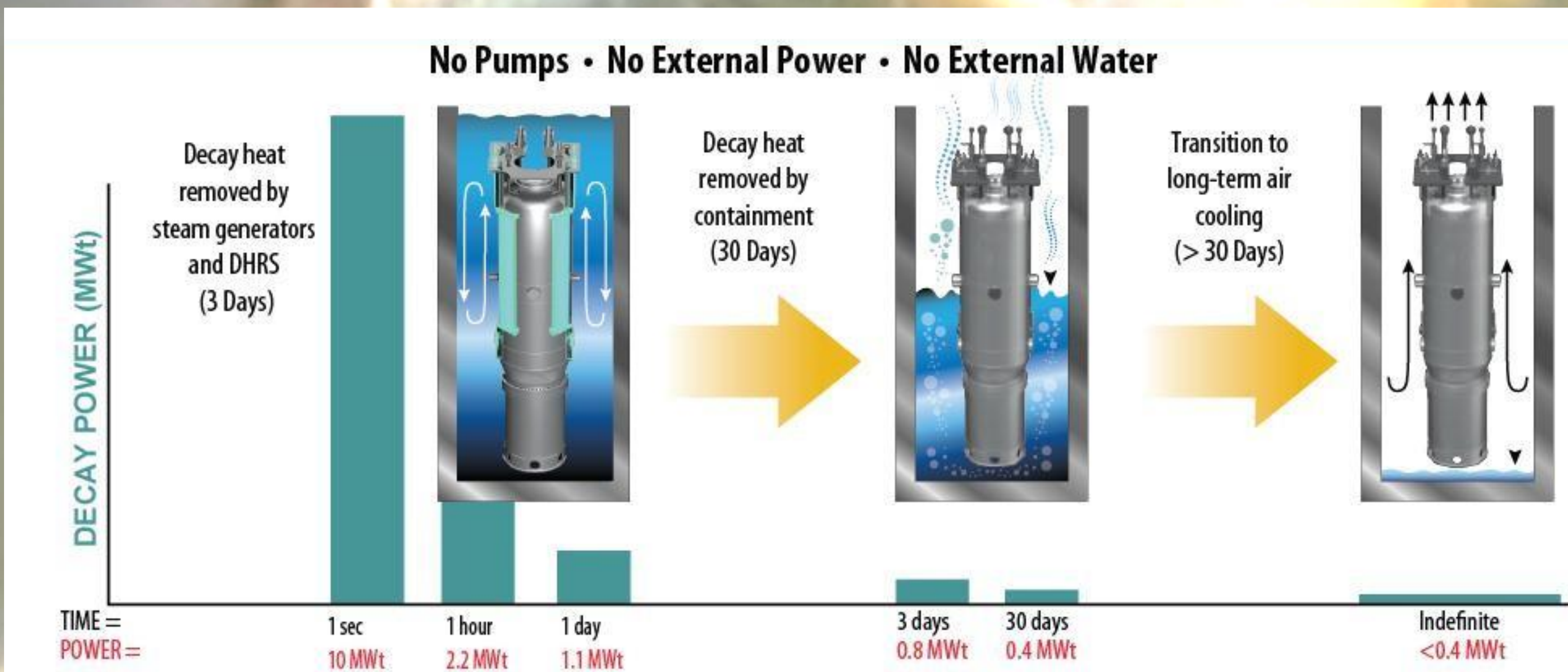


Ensuring Long-term Cool-down

Unlimited cooling of nuclear fuel without AC or DC power*

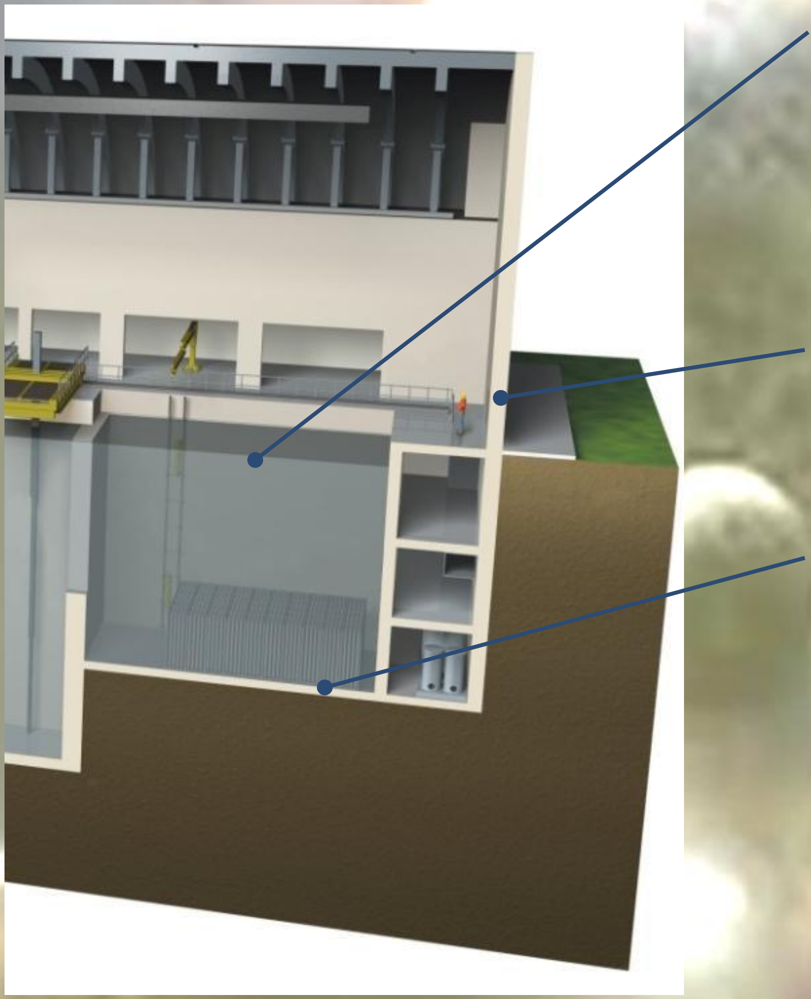
WATER COOLING | BOILING | AIR COOLING



Alternate 1E power system design eliminates the need for 1E qualified batteries to perform ESFAS protective functions

Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Spent Fuel Pool Safety



Increased Cooling Capacity

•*More water volume for cooling per fuel assembly* than current designs

•Redundant, cross-connected reactor and refueling pool heat exchangers provide full back-up cooling to spent fuel pool.

External Coolant Supply Connections

•Auxiliary *external water supply connections are easily accessible* to plant personnel and away from potential high radiation zones.

Below Ground, Robust Deep-Earth Structure

•Below ground spent fuel pool is housed in a *seismically robust reactor building.*

•Stainless steel refueling *pool liners are independent from concrete structure to retain integrity.*

•Pool wall located underground is *shielded from tsunami wave impact and damage.*

•*Construction of structure below ground in engineered soil limits the potential for any leakage.*

Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Response to Classic Accident Initiators

Design Basis Accident	NuScale Response
Steam system pipe break	**Reduced consequences** from lower energy release due to low steam generator inventory
Feedwater system pipe break	No change
Reactor coolant pump shaft failure	**Eliminated** with use of natural circulation of primary coolant
Control rod ejection accident	No change
Steam generator tube rupture	**Reduced likelihood** because tubes are in compression (shell-side primary flow)
Large break loss-of-coolant accident	**Eliminated** by use of integral design
Small break loss-of-coolant accident	**Reduced consequences** due to no heatup of fuel (already in natural circulation)
Design basis fuel handling accident	**Reduced consequences** due to smaller source term in half-height assemblies

Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

Probabilistic Risk Assessment Summary

- State-of-the-art process to evaluate all potential failures for a module
  - Risk = frequency of event x consequences
    - Used early in design process
    - Very low risk profile from internal events
  - Full Power Internal Events CDF = 2.9×10^{-9} module/yr = Probability of core damage due to NuScale reactor equipment failures is 1 in 345,000,000 years.
  - Operating nuclear reactors in the U.S. have a CDF of $\sim 1 \times 10^{-5}$ reactor/yr
- **Likelihood of an accident in NuScale reactor is >3,000 times lower compared to currently operating reactors in the US for a module**

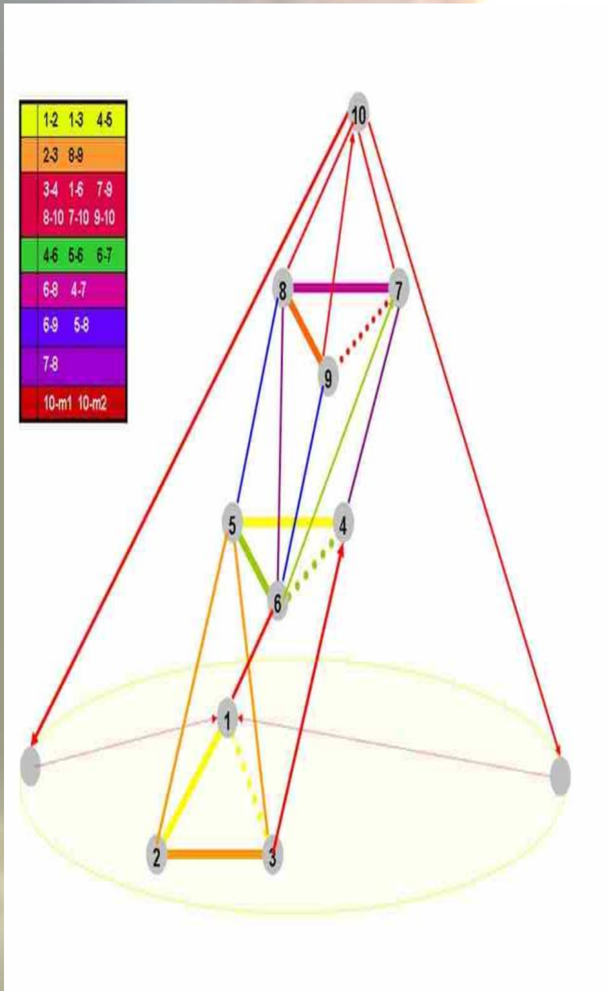
Source: Overview of NuScale Design, Chris Colbert -Chief Operating Officer - Technical Meeting on Technology Assessment of SMRs for Near-Term Deployment Chengdu, China -- September 2-4, 2013, Nonproprietary

ANNEX 8

ROMANIA

ASPECTE SPECIFICE DIN FIZICA SI ENERGETICA NUCLEARA

Extrase din lucrari publicate /comunicari ale autorului in perioada 2015-2020



1-*A*	**Definirea necesității**	**Avem o sursă unică de cunoaștere**
2-*B*	**Clarificarea diferențelor**	**Baza științei(lor) și a trăsăturilor sale / lor ca o abordare duală**
3-*C*	**Dezvoltarea principalelor 'unelte'**	**Crearea unei noi științe / revoluționarea uneia existente ca fiind guvernată de o abordare din trei- unghiuri de vedere (posibil – imposibil - probabil)**
4-*D*	**Verificarea stabilității elementelor definitorii pentru știința respectivă - teorii etc.**	**Durabilitatea unui element metodologic (teorie etc) așa cum rezultă din robustețea sa la paradoxuri**
5-*E*	**Identificarea principalelor convingeri care impiedică evoluția**	**Fiecare fază definită în cheie istorică a respectivei științe este alimentată de anumite convingeri / credințe și intuiții**
6-*F*	**Rafinarea cunoștințelor dobândite și imbunătățirea eficienței utilizării lor**	**Fiecare teorie trebuie să aibă un grad de utilitate în cadrul științei respective și al societății**
7-*G*	**Încercarea de a unifica metode pentru obținerea unor rezultate mai bune**	**Cunoașterea absolută și cea relativă**
8-*H*	**Gestionarea cunoștințelor acumulate**	**Existența și / sau introducerea / modificarea de ierarhii și conexiuni între diversele teorii ale unei științe conduc către nevoia de a avea unelte cât mai bune de gestionare a edificiului.**
9-*I*	**Încercarea continuă de a rezolva probleme nerezolvate și de a extinde cunoașterea**	**Nevoia de neînfrânat de a atinge noi niveluri de perfecțiune și înțelegere, ca o cauză continuă, latentă, de reîncepere a întregului proces de la zero.**

- **Case A - Procopiu magneton and Proca equations and pi meson**
- **Case B- Purica – research methods in nuclear experimental physics**
- **Case C - Hulubei – researches in nuclear physics and creation of an institute and a "school" of thought**
- **Case D - Romanian nuclear program**
- **Case E- An example of an individual experience of training and working in diverse cultural environments in nuclear energy**

CASE A – Procopiu-Proca

Procopiu magneton – calculation of the magnetic momentum of the electron

Synthesis - Plank theory and Bohr atomic model (having connections with classic mechanics)

Researches in the fields theory for nuclear forces –describing a field of - 1 spin and mass m in a Minkovski space – that will become the pi mezon, discovered by Yukawa – The theory is known as Proca equations.

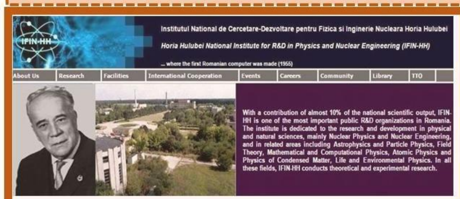
Contribution consists of performing a synthesis of Schrodinger equation and relativity theory – the resultant equations (Proca equations) were the basis for the discovery of pi mezon

→

Conflict bwtween two theories – need to find a solution in compliance with both –

Dilema in the approach to try to solve two conflicting theories. Solution is found by using a third solution integrating the two ones

CASE C -Hulubei and IFIN-HH



Three founding principles used by Hulubei for IFIN HH

- **Combined implementation and development and creative use of theoretical nuclear and quantic physics and nuclear engineering / technology**
- **Interface with and keeping the institute updated on international results – researchers training**
- **Inter and transdisciplinary researches**

→

Science management and development of national reference research groups –

Use of own expertise to set up the basis for a "national thought school" in physics and nuclear engineering so that to combine the national strong points and state of the art at the international level

CASE B - Purica

Methods in preparation and interpretation of the experiments in nuclear physics and nuclear reactors theory – modal logic

→

Dilemas in choosing the investigation and the specific results interpretation mof nuclear and quantic physics

for which

The use of the bivalent logic has severe limits

CASE D – Romanian National Nuclear Program started in the 70's

Creating research and engineering institutes, manufacturing facilities, including the know how, general management of the program and the interface with external partners and national/ international organizations

→

Nuclear program management – as management of s national critical infrastructure-

Maintain a set of objectives for society segments with diverse political and economical objectives

CASE E – An individual experience of education and training in diverse environments in the nuclear field

Education – Training
Reference books
on Nuclear Reactors Theory

"Classical" approach	Gleston & Edlund
Standard present approach (ex DOE)	Standard DOE
Western "anglo-saxon" type of training	North American type of training manual (ex AECL)
Russian type of training	Education/training Russian manuals
Romanian type of training	Manuals ex prof Berinde, prof Purica, prof M. Pavelescu, Dr. I. Cuculeanu

Diversity of approaches on the same topic – feature of a particular personal experience

- Experience gained during education period in diverse approaches
- Experience enhanced during PhD studies
- Training for working place at a new nuclear plant
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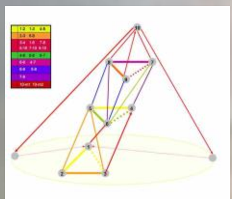
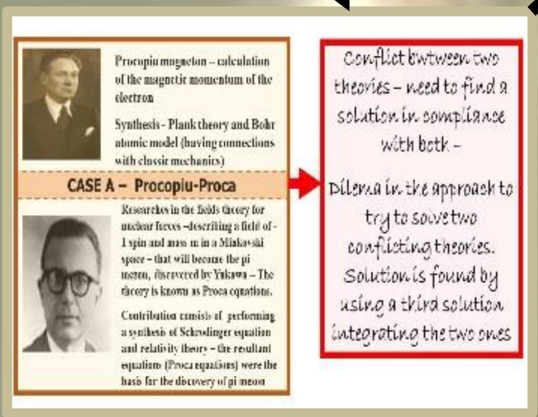
- Analyses and studies for new generation reactors in various countries and type of organizations

→

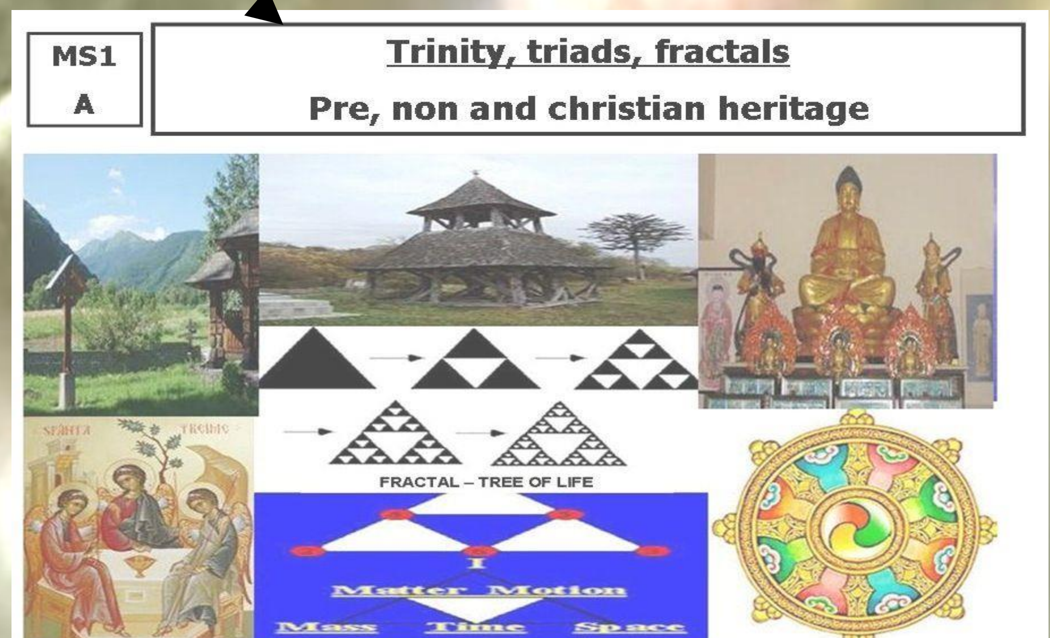
Education and training for the same knowledge from diverse perspectives and participation at activities related to nuclear physics and engineering at national and international level

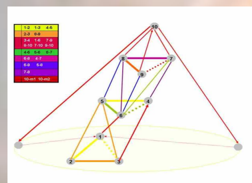




CASES A and B – Types of dominant phases 359

3 C	Develop the main tools/methods	Create a new approach and/or review an old one, being governed by the triad • Possible • Impossible • Probable
5 E	Identify the main believes that prevent evolution	Every phase - if defined from historical view of that science - is driven in by some believes and intuitions
9 I	There is a continuous attempt to solve unsolved problems and to expand knowledge	The unstoppable need to reach new perfection levels in knowledge level is a continuous latent root cause to restart the whole knowledge process from the begining





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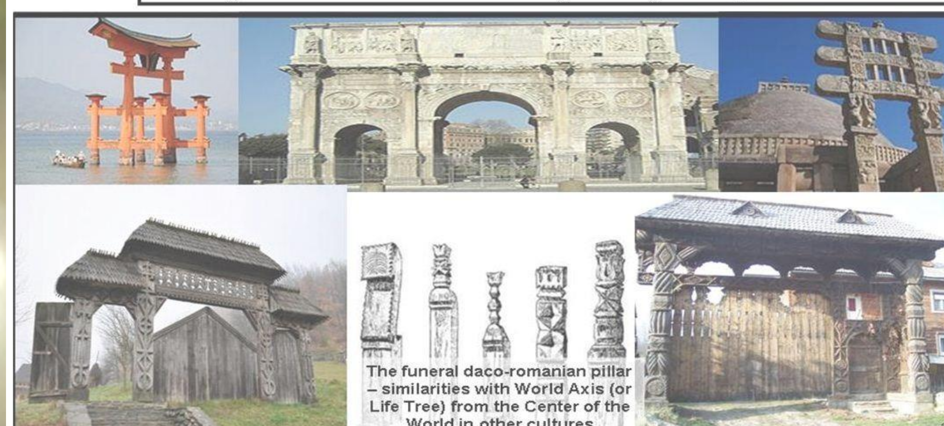
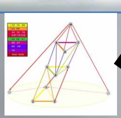
MS2 B

The Gate – The Pillar

- separation of the sacred and profane / impure spaces
- separation of solid, confirmed, recognized knowledge from the new, unconfirmed, uncertain
- strategies and tactics in the knowledge management process





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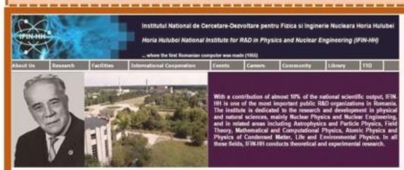

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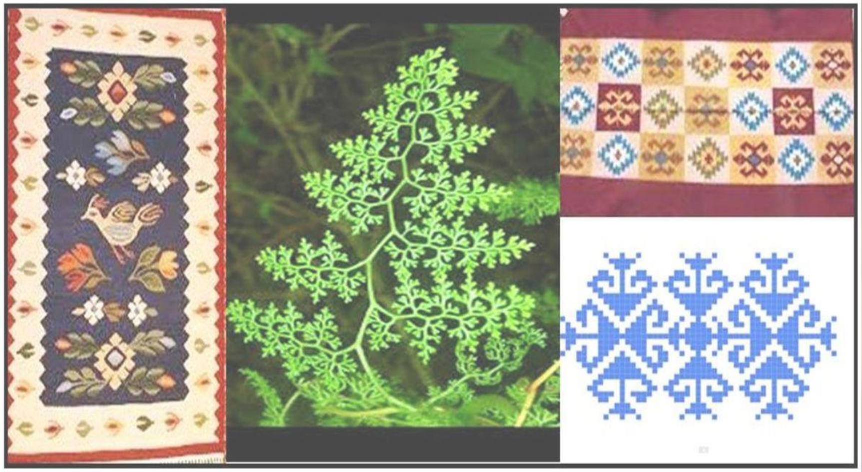
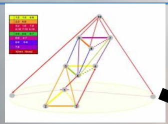
CASE C - Types of dominant phases 3568

3 C	Develop the main tools/methods	Create a new approach and/or review an old one, being governed by the triad • Possible • Impossible • Probable
5 C	Identify the main believes that prevent evolution	Every phase – if defined from historical view of that science - is driven in by some believes and intuitions
6 F	Refine the gained knowledge and improve the efficiency of their use	Every theory has to have a certain degree of usefulness in the given science and in the society as a whole
8 H	Manage the gained knowledge	Existence and / or definition an/or modification of hierarchies and connections between various theories lead to the need to have better tools to manage the knowledge corpus

MS3 C	**The world – cosmos and acquired knowledge on it as a set of infinite fractals**



MS4 C	**Hora, spiral – perfect form, solar and cosmic symbols, force and perfection of feelings, living and knowledge – role of colectivity in life and knowledge, changes and transformations of the world and of the knowledge corpus on it**



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CASE D and E - Types of dominant phases 35689

3 C	*Develop the main tools/methods*	*Create a new approach and/or review an old one, being governed by the triad: Possible, Impossible, Probable*
5 C	*Identify the main believes that prevent evolution*	*Every phase - if defined from historical view of that science - is driven in by some believes and intuitions*
6 F	*Refine the gained knowledge and improve the efficiency of their use*	*Every theory has to have a certain degree of usefulness in the given science and in the society as a whole*
8 H	*Manage the gained knowledge*	*Existence and / or definition an/or modification of hierarchies and connections between various theories lead to the need to have better tools to manage the knowledge corpus*
9 I	*Continuous attempt to solve unsolved yet problems and extend knowledge*	*Unstoppable need to reach new levels of perfection and understanding, as a perpetual latent root cause to restart the whole process*

MS5
D, E

Oikonomia - οἰκονομία - managementul the community and the environment – natural energy and traditional household – ecology "avant la lettre" – knowledge / risk analyses in systems naturalor built to immitate them – trans and interdisciplinary in solving problems

Sources of energy – knowledge and tradition in building them ▶

Sources of energy and the household – the user understood in an oikinomic manner

Οἰκονομία and ecology avant la lettre ▶

Sources of energy and the "expended" space – the community area (village etc) and the environment – the oikinomic management ▶