A new approach of the energy systems. An holistic vision and a bio-analogical structure

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Abstract: **The challenges have become clear: politically controlled fossil resources, aging energy infrastructure, rising of renewable technologIPS, distribution feature of these renewables, climate change exigencIPS, combined with a rise in domestic electricity consumption have forced the power industry to examine the status and health of our electrical systems. Solutions are on their ways: *Smart grid* - as a joined space of energy and information, *Enernet* - Bob Metcalfe's proposal for an analogy with internet. In our turn, we proposed a new approach to the energy systems and, at the same time, a holistic vision and an analogy with the autonomous functioning of the biological cells. In our view, the energy systems must be conceived as a whole that includes: consumer, generators, stores, metering infrastructures and grids. Advances in computing power and real time processing make such an approach possible.**

KeyWords: **energy sources, energy infrastructure, smart grids, real time processing**

Rezumat: Provocările au devenit clare: resursele de energie fosile controlate politic, infrastructura depășită, apariția tehnologiilor pentru resurse de energie regenerabile, caracteristicile specifice de distribuție a acestor resurse, exigențele referitoare la modificările climatice, combinate cu o sporire a consumului casnic de energie electrică au forțat industria energiei să examineze starea sistemelor noastre electrice. Soluțiile sunt în curs: un spațiu comun energiei și informației, Enernet, propunerea lui Bob Metcalfe ca o analogie cu Internet-ul. La rândul nostru, propunem o nouă abordare a sistemelor de energie, dar și o viziune holistică și o analogie cu funcționarea autonomă a celulelor biologice. Conform viziunii noastre, sistemele de energie trebuie tratateca un întreg, care cuprinde: consumatori, producători, depozite, infrastructuri de măsurări și rețele. Progresele în ceea ce privește puterea de calcul și procesarea în timp real a informațiilor fac posibilă o astfel de abordare.

Cuvinte cheie: resurse de energie, infrastructura energiei, rețele inteligente, prelucrare în timp real

1. Intelligent energy systems: generators, consumers, stores and grids; all intelligent

The smart grid – only a „half made" thing, because we must see the whole and not just some of its parts. Moreover, if the vision is not valuable or correct at the starting point, it could lead to a huge loss in the future. After all, we do not want a smart grid, we want an efficient power system. Therefore a safe and efficient energy system is desirable, to integrate distributed renewable generators and storage facilitIPS. One must think of an efficient and intelligent power system (IPS) as a whole. However, simply, a power system - as a whole - includes generators, stores, consumers, lines, measures and operation rules. This holistic new approach, IPS seen as a global entity, should change what today is percieved as power systems.

On the other hand, one can observe the trend or estimate the future trend that very large power plants (including nuclear plants) are no longer desired due to environmental constraints and to transmission losses. At the same time, small renewable sources appear everywhere as well as the distributed generators concept. The consumers were always distributed; in the future, the generators should be more and more distributed. As a consequence, the original radial grid and the present simple redundant grid would shift slowly to a complex cellular grid. However, in the real world, the radial grids still remain the appropriate power systems on narrow valleys.

IPS should be composed, at the same time, of intelligent consumers, intelligent generators, intelligent stores, smart grids and metering infrastructures and, what is very important, they should be accompanied by rules of real time management of the power flows. At the same time, IPS must be scalable in both directions, up and down. The IPS concept is applicable at the same time to small, local, national or to continental IPSs. Every IPS level, except the continental one, at the same time must have an advantage to be integrated in an upper level and to survive in a case of upper level failures.

Metering infrastructure is another component of IPS and should grant remote services. The IPS assumes a communication layer too, regardless of the type of communication technology IPS is using (wireless or broadband over power line, etc.). But the used transmission technology must have at least some basic characteristics, such as: bandwidth, IP-enabled digital communication, encryption and cyber security support.

Even in continental areas, like USA, isolated IPSs lately became significant ș1ț and that is normal - given the renewable development and its wide spreading. A large number of small arbitrary renewable sources would ask for more and more storage facilities, like compressed air, water pumping, heating and refrigerating, hydrogen generation, simple capacitors and batteries in order to be efficient.

2. Structure of an energy system as a tissue composed of cells with embedded behavior

The structure of the IPS must be modular. Such a structure has the advantages of being open, like a tissue of cells. The generic IPS is composed of cells or a cluster of cells. The subdivisions of the IPS are in their turn a smaller IPS and so on. The IPS must be able to isolate or to integrate subdivisions or cells of energy. It is very important that some subdivisions or cells could temporarily operate in an autonomous mode. In other words, even the structure of IPS must be smart. Not all cells must contain all the type of components. In some cells the storage facilities could be present, while other cells could be only consumers. Ideally, every cell must have multiple redundant ties to the grid. Some IPSs are frontier IPSs, behind them are „wild mountains, ice, or desserts". From a power point of view, IPSs could be nano (<10 W), micro (<10 kW), mini (<1 MW), local, national or continental. We could adopt for the nano, micro and mini IPS a more specific name: Intelligent Energy Cell (IEC), in which case the acronym IPS should

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be retained for larger systems. Finally, every cell must be intelligent, self managing, having its own encrypted behavior, having its own "DNA". Due to this DNA, or distributed intelligence, in the future, large IPS based on IEC could operate efficiently and securely without central dispatchers. Such an architecture: IPS of IPSs, IPS of IECs and IEC of IECs simplify coordination and communication without loss of synchronization.

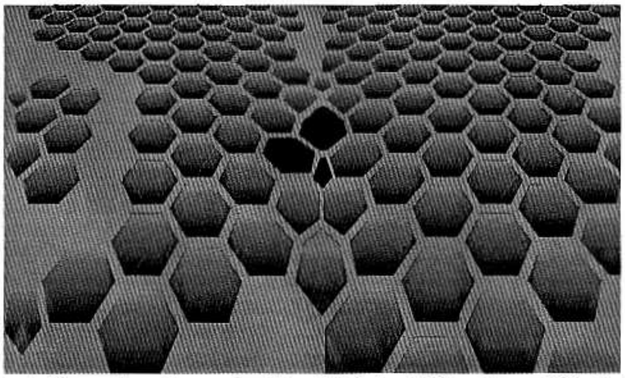

Fig. 1. Bio-analogy: tissue of cellular IPS; island IPS and large IPS with 3 isolated cells with inner problems

In this new vision, what does an intelligent consumer mean? It means, of course, a correct attitude with regard to consumption, which implies an intelligent behavior of the human beings and corporations, intelligent industrial processes (from the energy point of view) and intelligent appliances. An intelligent consumer, like washing machines, boilers or electrical vehicles (EV), must decide to go into standby or to accelerate the working or loading cycle. EV is a new electric device - it is both a consumer and a storage device. In future, when a large fleet of EVs is expected, using them without IPS rules could be a disaster, while in case of using them intelligently, their storage facilities could have a significant advantage. For example, in some instances, certain medical devices could require an energy supply, meaning that other consumers on the same circuit, which are not useful for the immediate medical task must go into a standby status. All these could happen if all consumers are themselves intelligent and are used in an intelligent IEC context. Intelligent consumers are technically and financially very plausible now. Significant financial effort must be exerted in the generator and communication domains. A new effort is required in the domain of rules and standards. Part of these rules or all of them can be encrypted in every cell. After the rules and the standards are agreed for the next 20-30 years, the present power system components will work along with the new intelligent devices.

3. The efficiency issue

How will the intelligence of such a system be in the future? Should the intelligence of IPS be concentrated as today's dispatchers or should it be dispersed in every cell of the system? A dispersed intelligence to every IPS or IEC is one way that reduces the need for a central control, which, paradoxically, leads to huge systems. We imagine it similar to the biology case: every cell has its own DNA, where all the possible interactions of the cell are encrypted. The IEC would have its own real-time opertion program. The proper "DNA" - the embedded behavior of every IPS and/or IEC, could be the future of the power systems. This encrypted intelligence will manage both the inner IEC relation and the inner relation in the foreign context demands. The external demands for power (peak load) or for storage capacities (power excess) are sufficient for a proper DNA to have a mutual and profitable relation within a larger IPS context. As a logic consequence, since intelligence is equally distributed to every actor of the IPS, the need for a central control diminishes. Perhaps it is too soon to see the central dispatcher disappear, but this could very well happen in the near future.

Nowadays, advances in artificial intelligence, data communications and real-time processing are quite sufficient to support the concept of an IPS, which must accommodate suppliers and consumers from a wide range of circumstances, with a greater economic efficiency. In the case of such a development, in the end, when all components would be intelligent, even a national IPS, for example, could work without any central dispatching. Very important for a large IPS is the fact that it could be divided into subdivisions that in extreme situations could operate in an autonomous mode. The same problems of efficiency of a large energy system would be encountered in an island grid or in an isolated small power system, or in a system temporary isolated from the large system that normally includes it.

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