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Hydrogen Civilization (HyCi) doctrine (study, concept, conception) is a novel world outlook, all-embracing vision of the sustainability of the human future: humanity can preclude world climate and ecological catastrophe and conserve the biosphere’s ability to maintain the life of humanity by the only way, just by the sustainable movement along the vector “Hydrogen Energy → Hydrogen Economy → Hydrogen Civilization”. HyCi doctrine is overcoming boundaries between different sciences, between peoples and nations. Hydrogen civilization is a public ideal (‘superattractor’) putting in the forefront Shakespeare’s Hamlet question on a global scale: “To be or not to be **the humankind**: that is the question”.

The review is intended for experts of different disciplines (natural sciences, social sciences, economical sciences, philosophy, humanities), of different spheres of intellectual human activities (environmental, cultural, political, technical) for the members of the world hydrogen movement working for our sustainable future.

It will be highly useful for students, post-graduates and young scientists who are interested in history and development of hydrogen energy (hydrogen economy), who is deep in thought of sustainable human future.

Keywords: hydrogen energy; hydrogen economy; hydrogen civilization; sustainability

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Sustainable Human Future, Hydrogen Civilization

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*Over and again have nations and civilization
been confronted with problems, which,
like the riddle of the Sphinx,
not to answer was to be destroyed.*

‘Social Problems’
Henry George
(1830–1897)

1. Introduction: Hydrogen Idea Advance, Historical View

Hydrogen because of its chemical nature can serve as an effective source of energy. And this ‘hydrogen idea’ has been systematically attracting scientists and engineers’ attention during about two hundred years. But, as is well known from science and technics history [1,2] *even greatest fundamental ideas give rise to public echo and may be realized in the life only and only in the time, when there appears an industrial suitable demand and public aspiration* [2].

Just in accordance with this historical tendency hydrogen idea had its origin and development in the 20th century. Really, in the 20th century there was completely formed the economy based on fossil fuels (first of all on oil and natural gas). Side by side with a permanent achievement of successes, the oil and gas economy gradually and inevitably leads the mankind to a worldwide ecological catastrophe and global geopolitical shocks (because of exhaustibility of the world resources of oil and gas and an inadequate awareness of a world ecological catastrophe threat).

Environmental hazards of such a way of the human life were deeply understood already in the first half of the 20th century. Vladimir I. Vernadsky, the greatest thinker of the 21st century, the founder of the biospheric and noospheric studies, perceived both the geological vastness of human activity, and the unpredictability of its consequences [3–6]. He wrote: ‘We observe a more and more dramatic influence of a human intellection and collective mind on geochemical processes’; ‘Of special interest is a characteristic fact of the carbon history, it is the fact that the carbon dioxide content at the atmosphere increases as the human civilization evolves’; ‘In this way a civilized person disrupts the equilibrium established on the Earth’. Vernadsky emotionally stressed, ‘Here human beings behave not like *Homo sapiens* but like *Homo sapiens faber*’. He exclaimed, ‘Where will this new geological process stop? And will it stop or not?’

In the 20th century, at a period from the first years of the 20-ies to the first years of the 70-ies, thanks to enthusiasm of conscientious representatives of the world scientific community, the fantastic idea of the great French writer Jules Verne was revived. Really, just J. Verne was the first who formulated a fantastic idea [7]: in the future the humankind will heat himself by water, dissociating it into hydrogen and oxygen, and then burning hydrogen. At a period indicated above this fantastic hydrogen idea of J. Verne was not only revived but it was developed and brought to a great scientific and engineering level (see generalizing book of Jon O’M Bockris [8]), in which he called personally all the hydrogen enthusiasts of that time: J.B.S. Haldane (1923), A.T. Stuart (1927, 1934). R. Erren (1933), Niederresther (1937), Sikorski (1938), King (1948), Bacan *et al.* (1950), Lessing (1961), Lindstrom *et al.* (1963), Justi (1965), Jon O’M. Bockris (1971, 1972), D.P. Gregory (1972), C. Marchetti (1973). In the brackets there are given years of some their publications. And an important point is that Bockris reviewed their works and ideas [8]. Indeed, hydrogen idea was carefully developed at that time and even the phrase ‘A Hydrogen Economy’ was used for the first time by Bockris and Triner, 03 February 1970 and after that by some others (see in [8,9]).

But all these hydrogen idea achievements didn’t give rise to public echo and were not perceived by industry based on fossil fuels. There was only one special, but not typical, case. During the Great Patriotic War in the Soviet Union

in blockade Leningrad military technician–lieutenant Boris I. Shelishch successfully used (1941–1942) hydrogen–air mixture from the barrage balloons as a fuel (instead of gasoline) in engines of autos GAZ-AA on a large scale [10]: 200 trucks were converted to hydrogen.

So, from viewpoint of the history of technique development there is nothing to wonder that only the world crisis of the 70s changed step by step human perceiving hydrogen idea.

Really, at the height of the fuel and energy crisis of the 70s during the Hydrogen Economy Miami Energy (THEME) Conference (18–20 March, 1974) organized and chaired by T. Nejat Veziroğlu, the consensus was developed by ‘the Hydrogen Romantics’ (Hussein K. Abdel-Aal, Jon O’M. Bockris, William J.D. Escher, Cesare Marchetti, Anibal R. Martinez, Tokio Ohta, Walter Seifritz, William D. Van Vorst, T. Nejat Veziroğlu, Kurt H. Weil and Robert M. Zweig) that the Hydrogen Energy System offers the optimum solution to the interrelated world problems. On a global scale they said ‘The Hydrogen Energy System time had arrived’ [11–19]. And in 1974, the International Association for Hydrogen Energy (IAHE) was established (Dr. Veziroğlu, Founding President) with its headquarters in the Clean Energy Research Institute of Miami University (USA). IAHE began publishing the *International Journal of Hydrogen Energy (IJHE)*, and started organizing the biennial World Hydrogen Energy Conferences (WHEC) to provide a platform for forming the Hydrogen Energy community [19].

During the same time in the USSR, owing to the activity of Valery Alexeevich Legasov [20–22], Anatoly Nickolaevich Podgorny [23] and their scientific adherents (see [20–23]), hydrogen energy started to be intensively researched. A wider energy–technological version of the hydrogen energy concept, namely ‘Nuclear Hydrogen Energy and Technology’ was steadily worked out by the Institute of Atomic Energy, named by I.V. Kurchatov, and some other scientific and technological organizations (V.A. Legasov – key leader). The application of hydrogen as a fuel for car engines and using hydrides for its storage were worked on by the Institute of Mechanical and Engineering Problems (A.N. Podgorny – key leader). Hydrogen as a fuel in aviation and all other aspects of hydrogen energy also came to the attention of the hydrogen community of the USSR. In 1975, at the All-Union Scientific and Technological Seminar ‘Gases and Metals’ (Donetsk, Ukraine, 1975; Chairman V.A. Goltsov) hydrogen energy was thoroughly discussed, and *for the first time, it was pointed out that: ‘Hydrogen-Materials Problem and Materials Safety are an integral part of Hydrogen Energy concept’*. From then, regular All-Union conferences and seminars (Moscow, Donetsk) and All-Union schools for young scientists were organized (Donetsk, Ionava, Tula, etc.), every one of which was attracting 250–500 participants (scientists, engineers, and industrial managers). Every year

collections of analytical reviews and scientific–technological works [22], were published (every book consisted of 250–300 pages). As a result, there was an official acceptance of the hydrogen energy concept and the USSR joined the IAHE.

Based on the decision of the USSR State Committee on Science and Technology – in 1977 the Donetsk State Hydrogen Laboratory was established at the Donetsk Polytechnic Institute (nowadays Donetsk National Technical University), for steadily developing the hydrogen–materials problem [24–33] and for scientometric analysis of world hydrogen energy development [34,35]. In accordance with the agreement between T.N. Veziroğlu and V.A. Legasov, the Donetsk State Hydrogen Laboratory and the Institute of Atomic Energy prepared *IJHE* annual reports about the ‘hydrogen’ works published in the Soviet Union [36]. A partnership for ongoing scientometric investigation of the progress of hydrogen energy was established [35] and systematic analysis of the latest development of the world hydrogen movement was to be fulfilling [37].

2. The Last Quarter of the 20th Century: from Hydrogen Energy to Hydrogen Economy

The late 1970s and 1980s were years of very rapid progress in the development of hydrogen energy. It is impossible to mention all the important works of that period (see *IJHE* and [20,22]), and we cite here only some references to research which made, in my opinion, a noticeable effect on the developing hydrogen movement [38–44].

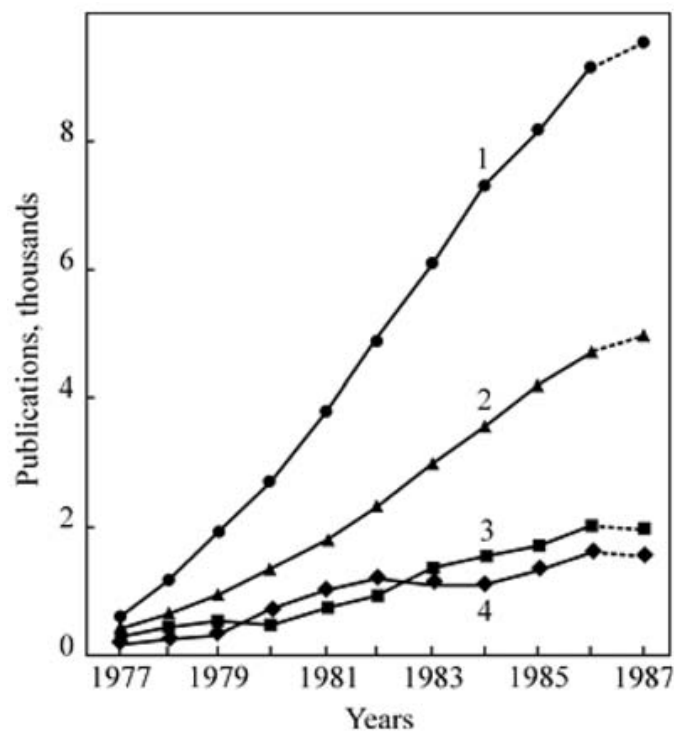
Scientometric studies of world hydrogen energy development during 1977–1988 have been reviewed in Goltsova et al. [35]. A file of 10,573 units was analyzed. It was found that investigation of hydrogen energy had been carried out in 39 countries and information had been published in 21 languages. Therewith publications in English, Russian, Japanese, German and French amounted to ~98% of the total. The core group of journals included two international journals, namely *International Journal of Hydrogen Energy* and *Journal of the Less-Common Metals* (nowadays known as *Journal of Alloys and Compounds*), and the Soviet journal *Voprosy Atomnoi Nauki i Tekhniki. Ser. Atomno-Vodorodnaya Energetika i Tekhnologiya* that carried about 30% of the total publications on the problem.

World hydrogen energy development during 1977–1987 is presented in Figure 1. One can see a very rapid progress for this period represented by: the world total volume of publications (curve 1), the volume of periodicals (curve 2), patent documents (curve 3) and conference reports (curve 4). The growth of the world hydrogen community was reflected in 250 symposia on hydrogen energy and related problems held during these years [35].

In this work [35], an informetric analysis had been carried out and the scientific–information structure of hydrogen energy had been systematically studied and substantiated. It had 211 rubrics including nine rubrics of the first level, 40 rubrics of the second level, 66 rubrics of the third level, 85 rubrics of the fourth level, nine rubrics of the fifth level and two rubrics of the sixth level (see Appendix in [35]).

This classification served as the basis to draw the subject boundaries and was the basis for the information retrieval system on the scientific problems of hydrogen energy.

Figure 1. Database on hydrogen energy and technology [35]: the total number of publications (1); periodicals (2); patent documents (3); conference reports (4).



It is very important to keep in mind that already in the last decades of the 21st century the term ‘hydrogen energy’ contains information about two aspects of the problem [35].

On the one hand, a new rapidly advancing trend in science and engineering termed ‘hydrogen energy’ had been sculptured in the 1970–1980s as a large-scale unified scientific–technological problem having its own subject matter, structure, aim and tasks.

On the other hand, ‘hydrogen energy’ had already been a new large-scale concept pointing to a new environmentally friendly vector for industrial development.

In short the ‘hydrogen energy’ structure comprises [35]:

- hydrogen production from water using non-renewable energy sources (coal, natural gas, oil, atomic energy and in the far future thermonuclear energy) and renewable energy sources (sun, wind, hydroelectric, biomass and others);
- hydrogen delivery, transportation and storage;
- hydrogen utilization in industry, transport (land, water and air) and home;
- problems of materials and safety.

The world hydrogen movement had been growing very quickly and that was how matters stood in the late 1980s.

Since the world economy runs on energy, the term ‘hydrogen economy’ [8] has received a wider usage in the last decade of the 20th century. Then, as a result of the beginning of commercialization of the hydrogen technique and technology, the concept of the hydrogen economy emerged [16–19].

By and large, the results of the hydrogen energy and hydrogen economy development within the last quarter of the 20th century are summed up in [16–19]. The results are impressive. Some countries had adopted national programs and/or initiated large hydrogen projects (e.g. Japan, Germany, USA and some others). Already at that time some companies had already begun to commercialize hydrogen technologies, hydrogen know-how and hydrogen energy systems, e.g. automobiles running on hydrogen fuel, fuel cells, improved electrolyzers, hydrogen–nickel batteries, and so on. A stable hydrogen scientific community had been formed. They had begun to study the prospects of developing separate aspects of the hydrogen economy up to 2020, 2050, and even up to 2100 [45–49]. The research being carried out covered either a region and/or certain technical aspects of the hydrogen economy. For example, there were studies, which were pertinent to the USA, Brazil, Spain, Egypt, Iceland, etc. They were studying prognostic problems of the hydrogen energy system requirements for the future, the electrical energy required for hydrogen production, and other similar questions. From an engineer’s viewpoint, such an approach is fully justified; it makes it possible to forecast and later on solve the important technical and economical problems of hydrogen economy.

3. The First Years of the 21st Century: Hydrogen Economy Progression and IAHE Hydrogen Civilization Concept Origination and Development

During previous years, the hydrogen economy has been gathering force in all possible directions: fuel cells, hydrogen cars and hydrogen refueling stations, Me–H-batteries, improved electrolyzers, other hydrogen technologies and hydrogen energy systems. This has been demonstrated with a rapid growth of

the amount of worldwide hydrogen refueling stations. In 2003 there were about 40 hydrogen refueling stations in the world, but 220 were operating by 2005. One can find full information in the internet, in the public press, in scientific journals, in proceedings of international hydrogen conferences (see, for example, Proceedings of the 14th World Hydrogen Energy Conference (The Hydrogen Planet), 2002 [50], Fourth International Conference ‘Hydrogen Treatment of Materials. HTM-2004’, 2004 [51]; Proceedings of International Hydrogen Energy Congress & Exhibition, 2005 [52] and references therein.

A very important point is that in many countries the hydrogen economy problem was being considered at governmental and inter-governmental levels. The Japanese government was planning to increase fuel cell production rapidly. To 2010, 2020 and 2030 there will be produced cars with fuel cells 50,000, 5,000,000 and 15,000,000, respectively. Stationary energy systems with fuel cells will have power 2200 MW, 10,000 MW and 12,500 MW, correspondingly.

The USA and Europe have their own ambitious plans for support of the hydrogen economy: to accelerate the development of hydrogen and fuel cell technologies, to improve their energy security, environmental security and economic security.

Hydrogen economy advancement has provided the necessary practical background for the further understanding of the sustainable far-distant future of humanity.

Really, at the end of the 20th century human activity in use of fossil fuels approached an unreasonable scale and the world biosphere and climate catastrophe became a near historical threat. Following after Vernadsky it became possible to say with a sorrowful irony: ‘Now human beings behave not like ‘*Homo sapiens faber*’ but like ‘*Homo desipiens faber*’, a man working without mind’ [53]. In another words, we are approaching (or may be have already entered) a civilization of ‘*Homo desipiens faber*’. Really, deterioration of biosphere gets out of rational frame work: green-house effect, global warming and degradation of climate; ozone layer depletion, ozone holes appearance and their growth; acid rains; degradation and decrease of productive soil (see also Appendix 1).

Now I would like to remind a deep thought of the great American thinker Henry George, which is an epigraph of this work, and repeat the last its sentence: ‘Not to answer was to be destroyed’.

Thinking on the basis of Vernadsky’s biosphere and noosphere doctrine about this human dilemma (to be or not to be) and leaning upon hydrogen economy advances has originated a novel understanding of the Future of Human Sustainability. And a novel large-scale Hydrogen Civilization (HyCi-) concept (conception) has been conceived [53,54]. So, for the first time, the main aspects of humanity move into the era of an ecologically clean hydrogen civilization

were being pondered. Some biospheric and noospheric consequences of this transition were analyzed and the tasks of the world hydrogen movement formulated.

There was perceived [53,54] that historically prolonged movement into the era of Hydrogen Civilization will lead to global transformations in all aspects of human existence, human mentality and human society, the mode of political and international thought, environment and hydrogen industry friendly development. For the first time this planetary problem has been raised officially at the International Vernadsky's Conference in the Donetsk National Technical University (Donetsk, Ukraine, April 10–12, 2001) [53,54]. At the Plenary Session V.A. Goltsov adduced arguments and called up: 'Negative climate and biosphere changes analyzed on the basis of Vernadsky's doctrine make hydrogen civilization transition to be especially acute for thinking out just now, not at a later time!'

Now let us note some milestones in the development of the HyCi concept. In 2001, the first worldwide international discussion on the HyCi concept was presented by V.A. Goltsov and T.N. Veziroğlu [55] during the Third International Conference 'HTM-2001' (Donetsk, Ukraine, May 14–18, 2001). Scientists and industrialists from Russia, USA, UK, Ukraine, Japan, France, Poland and other countries discussed the HyCi concept and accepted the 'Memorandum on the Transition from Fossil System to Hydrogen Economy and then to Hydrogen Civilization'.

The Memorandum was published in a Special Issue of *IJHE* [56]. It called: 'all the members of the hydrogen energy and ecological movements, everybody who cares for the ecological well-being of the humankind, preservation of the Earth's biosphere and ecosystem, to consolidate the efforts and to contribute to the approaching of the era of hydrogen civilization, the only ecologically clean and worthy civilization of the future' [56].

The views of the HyCi concept on the future of humanity on a global scale were published in *IJHE* [57,58].

On June 12, 2002 at the Meeting of Board of Directors of IAHE held in Montreal (WHEC-14), pioneered by Board Director Dr. J. Bolcich discussion of the novel IAHE HyCi concept had taken place and the presentation of the IAHE HyCi concept to the World Hydrogen Movement at the 15th World Hydrogen Energy Conference in Yokohama was recommended. This decision was fulfilled in the 30th anniversary year of the IAHE during the 15th World Hydrogen Energy Conference (Yokohama, Japan, June 27–July 2, 2004). The concept was presented at the Plenary Session to an audience of 2000 delegates from 52 countries. Following this, at the first years of the 21st century the novel IAHE HyCi concept was widely presented to the scientific community at the

international hydrogen conferences: Istanbul-2005, Moscow-2006, Lyon-2006, Berlin-2006, Istanbul-2007, Donetsk-2007, Montecatini Terme-2007, Moscow-2008, Xi'an-2008, Delhi-2009, Moscow-2009 and were published in IJHE, IJNHPA and in many other journals and conference proceedings [59–83].

Comprehensive data on the HyCi concept status in the World Hydrogen Movement are well represented by ‘Memorandum on a Novel IAHE Conception of Hydrogen Civilization of the Future: Historical Aspects and New Challenges of the Present Day’ [2]. Additional information please see in the Daily Report No. 3 of WHEC-16 in Lyon, France (Appendix 1).

By now Hydrogen Civilization Concept (Conception) has made great strides toward its maturity [59–83] and might be symbolized by other proper terms, ‘study’ or ‘doctrine’.

In this review the term ‘doctrine’ will be used to identify a novel world outlook, all-embracing vision of the sustainability of the human future.

4. The Essence of HyCi Doctrine

The general principle (‘principium’ in Latin) of HyCi doctrine is this: *humanity can preclude world ecological catastrophe and conserve the biosphere’s ability to sustain the life only by movement along the vector: ‘Hydrogen Energy → Hydrogen Economy → Hydrogen Civilization’*. The HyCi doctrine has a program nature and consists of interrelated and mutually conditioned basic constituents: industrial–ecological, humanitarian–cultural, geopolitical–internationally legislative ones.

The *industrial–ecological* constituent of the HyCi doctrine has its origins in the progress of hydrogen economy and encompasses the historical scientific viewpoint on interrelated development of the world ecological situation and hydrogen industry on a global scale. Being based, first of all, on Vernadsky’s studies concerning the biosphere, the HyCi doctrine leans in its following analysis upon synergetics, a modern science about the development of complex self-organizing systems, of which the biosphere is an example. Important point of the industrial–ecological constituent: climate and ecology, changes of environmental, industrial and other activities of humanity are nothing more than biosphere’s functions and a manifestation of biosphere nature. So, correct viewing and solving above problems can be entirely refined from the biosphere angle only.

The *humanitarian–cultural* constituent of the HyCi doctrine emerges from Vernadsky’s studies about the noosphere and his cultural–philosophical heritage. In its development, this part of the HyCi doctrine is guided by the humanities: modern philosophy, culturology and others. Distinctive standpoint of humanitarian–cultural constituent: mass and elitist hydrogen–ecological

consciousness is a spiritual basis of the sustainable human civilization of the future, Hydrogen Civilization. Correspondingly, hydrogen–ecological consciousness introduction is to be of the most important objective in the coming decades. So, the historical task of the HyCi doctrine in its humanitarian–cultural aspect consists of the ideology formation and propagation of hydrogen–ecological and noospheric consciousness of people of some countries firstly, and then of all humanity.

The *geopolitical–internationally legislative* constituent of the HyCi doctrine. Being all-planetary process the conversion ‘Hydrogen energy → Hydrogen economy → Hydrogen civilization’ should be resolved in frames of the world legislative field elaborated by international and national organizations, first of all under the auspices of UN and its structural organizations (UNIDO, UNESCO etc.). Transition to hydrogen economy and then to hydrogen civilization will undoubtedly be accompanied by permanent global and/or local geopolitical and geoeconomical contradictions. In particular, changes in the national interests of many countries will take place – ‘old’ and ‘new’ energy resource owners, changes of geoeconomical interests of transnational energy companies. A polarity reversal might arise in the sphere of geopolitical and geoeconomical attractions and the like. Generalized task of political elite and of all the humankind is to work steadily under legislative (not by force) governing of possible negative geopolitical and geoeconomical tendencies of the movement on the road to hydrogen civilization.

The framework laws (recommended by international organizations to the national parliaments and governments), which would outline scientifically and economically founded ways and mechanisms for the transition to hydrogen civilization, are to be accepted.

National parliaments on the basis of framework laws must accept national laws taking into account specific conditions of individual countries, the living standard of the country, its economic state, scientific potential, environment and so on. The designing and adoption of national laws should be followed by regulation of financing and establishing of comprehensively organized national enterprises, which would encourage the use of hydrogen, investment of private capital and the establishment of a competitive market for the power hydrogen.

The transition into the era of hydrogen civilization will be a particularly synergetic multilayer process and all constituents of HyCi doctrine (industrial–ecological, humanitarian–cultural, geopolitical–internationally legislative ones) will be realized and transformed interdependently and in a mutual coordination.

Specific HyCi doctrine statement: a novel vision of hydrogen energy and hydrogen economy. Hydrogen energy and hydrogen economy are technical, economical and ecological groundwork of the conversion to the sustainable human future, hydrogen civilization. It

means that any hydrogen energy and economy advance, any new investigation of its partial problems is a step forward on the road to Hydrogen Civilization. At present day in actual truth all the work of the World Hydrogen Movement is serving the achievement of sustainable human future, Hydrogen Civilization.

5. The Global Aspect of the HyCi Doctrine

5.1. Vernadsky's Biosphere and Noosphere Study – Groundwork of the HyCi Doctrine

On a planetary scale, the HyCi doctrine is based on Vernadsky's studies about the biosphere and the noosphere [1,3–5]. The biosphere, in accordance with Vernadsky's study, is an ' . . . organized, specific crust envelope of the Earth associated (mated) with life.' So, the biosphere is bounded first and foremost by the region where life exists, and living matter and humanity is the primary driving force of the evolution of the biosphere over geological and historical timescales. Upper limit of the biosphere space includes all the troposphere on the verge of ozone layer (i.e. about 23–25 km). On the Earth's surface biosphere includes World Ocean, hydrosphere of the land and of course all dry land of the Earth. In the Earth depth it extends to about 16 km below the Earth's surface level.

Living matter of the biosphere consists of all types of microbes, plants, animals and humanity. The main point of the Vernadsky's study is that during historical time scale humanity became (and is) *leading* driving force of the biosphere development.

A very important point is that the biosphere is permanently in a state of energy and matter exchange with outer space, with the rest of the central part of the planet Earth, with its upper atmosphere and with outer space. So, the biosphere is a too highest degree non-equilibrium system. From the modern viewpoint biosphere is a self-organizing, *synergetic* system.

Now let us look at the Earth as a heavenly body which exchanges energy and matter with outer space. Matter reaches Earth as meteorites, space dust, microparticles, elementary particles of solar and space wind, etc. The Earth derives energy first of all in the form of solar radiation, and, to a smaller extent, from other space objects in the form of electromagnetic radiation, microparticle energy, etc. Solar radiation is certainly the foremost factor in the existence and functioning of the biosphere, and in what follows, we shall consider just this energy source.

The entire solar energy the Earth derives can be divided roughly into certain parts. One part is the Earth's thermal absorbing and radiation. Basically, thermal radiation is long-wave electromagnetic radiation. It passes partially

through the Earth's atmospheric shell and proceeds into outer space. Some of this Earth-based radiation is blocked, speaking figuratively, by the atmospheric shell as if by an atmospheric 'blanket'. The Earth-space energy exchange results in steady-state conditions, and our planet is warm (in comparison with space temperature) and supports the life forms on it. The other part of the solar radiation the Earth derives is converted by the biosphere (mostly, through the work of plant life) into storable forms of chemical energy.

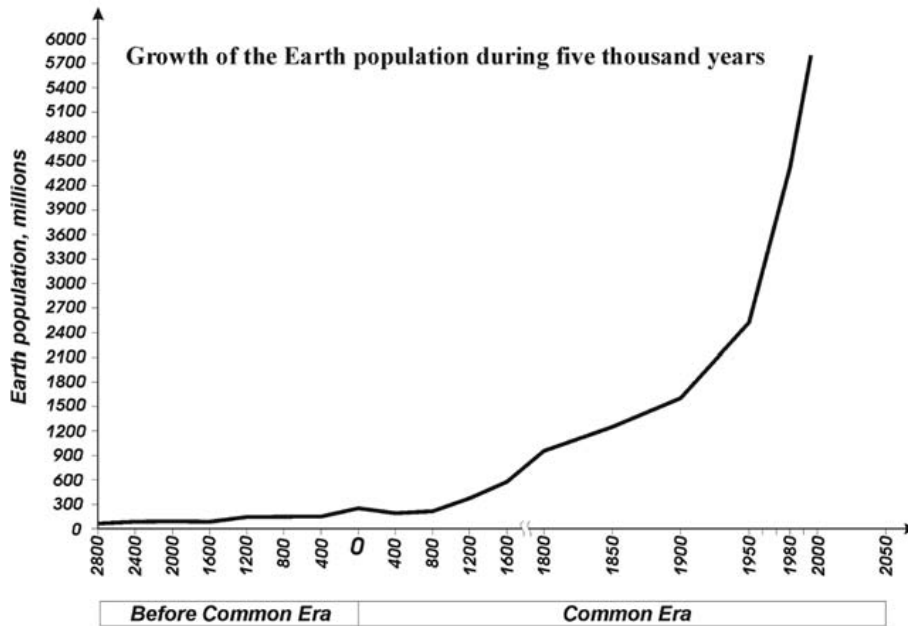
According to the scientific knowledge of his time, and even ahead of it, Vernadsky has elaborated in detail all aspects of biosphere functioning during geological and historical periods of time. He had particularly identified and analyzed in every detail the cycles of chemical elements – components of living substances (living matter). Vernadsky had shown that these cycles, in modern terms, are self-sustainable stationary ones. Thermodynamically they are not closed and, for example, over the course of geological time, a part of the matter and energy leaves them, being stored in the crust and forming such deposits as coal, oil, etc.

In the context of the HyCi doctrine, the carbon cycle is of particular interest. In this cycle, carbon dioxide, being a general cause for the greenhouse effect, plays a great role. It is emitted into the Earth's atmosphere through the industrial and vital activities of human life and through the vital activity of animal life, and is absorbed and processed by plant life (with the release of oxygen into the atmosphere). It is to be involving in the continuous formation of minerals on land and in the aquatic environment.

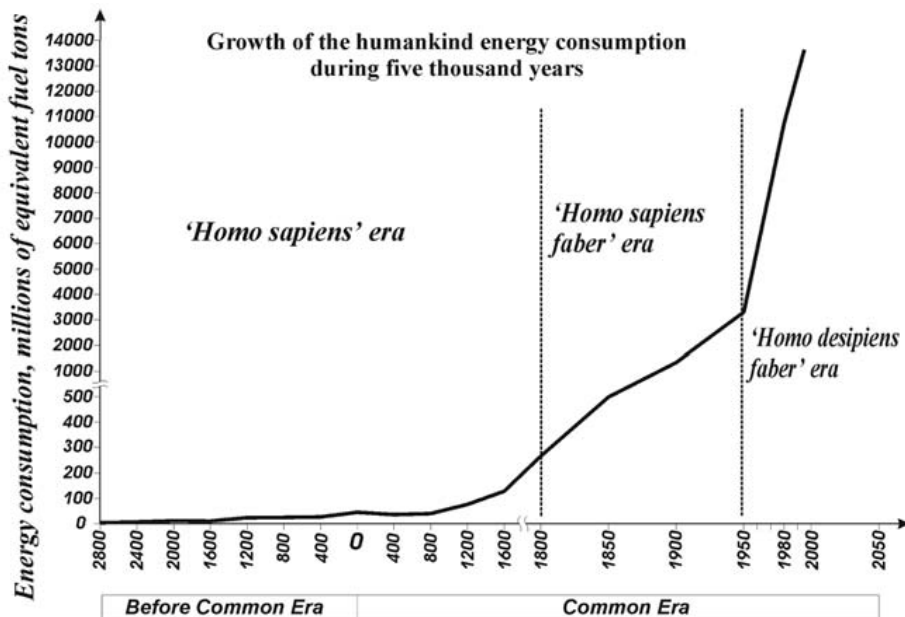
As we already underline in the Introduction of the paper, Vernadsky perceived both the geological waste caused by human activity and the unpredictability of its consequences. We'll repeat that Vernadsky emotionally emphasized: 'Here human beings behave not like *Homo sapiens* but like *Homo sapiens faber*.'

More than six decades since the great thinker's death, we see that answers to his questions are negative. Really, the population of the Earth [84] has continued to grow more rapidly than in Vernadsky's times. That is clearly demonstrated in Figure 2a. And at the same time a dramatic growth of energy consumption has taken place (Figure 2b). So, during 5000 years the population of the Earth has grown 144 times, but energy consumption has increased by 2650 times. One can feel this difference is of fundamental importance. With a sad irony it has been said [53,54] that during the last decades humanity has been acting not like '*Homo sapiens faber*', but like '*Homo desipiens faber*' (working person without mind). Really, we live already in the Era of '*Homo desipiens faber*' (Figure 2b)!

Figure 2. Growth of the Earth's population (a) and energy consumption (b) over 5000 years [84].



(a)



(b)

From viewpoint of this work I would like to stress too highly only one point of prime importance for understanding it by educated society of the present time: *climate, ecology, human environments and all forms of human activity are no more than constituents of the biosphere, no more than its functioning. It means that every above mentioned modern human problem of crucial importance can't be solved by itself against paying attention to the biosphere as a unit.*

The noosphere, according to Vernadsky, is a special stage of the biosphere development when a dominant driving force of its self-development is science, with human intellectual activity as a general planetary phenomenon.

It is obvious that *humankind movement along the vector 'Hydrogen energy → Hydrogen economy → Hydrogen civilization' truly is of a noospherical scale and must be based on a human intellectual activity as a general planetary phenomenon.*

5.2. Irreversible Catastrophe or Hydrogen Civilization?

In the light of what is written above, a key question arises: is world ecological catastrophe possible or not? And, if it is possible, then what period of time do we have to prevent this catastrophe? Another important question, connected to the above is: how will be the biosphere developing in the future, depending on whether the humankind is (or not) moving on the road to hydrogen civilization? In this context, the HyCi doctrine impinges on the new interdisciplinary science of synergetics [85–88].

A characteristic property of synergetic systems is that on the pathways of their development there may exist so-called bifurcation points (periods), wherein the possible system development routes may fork. An important point here is that at such a time the system is in an unstable state and small random disturbances can lead to global impacts: the system could irreversibly progress in the direction of one of the earlier possible routes which can be absolutely and fundamentally different from the other probable variants of development.

The biosphere is a synergetic, to a highest degree, non-equilibrium self-organizing system. As said above, it exchanges energy and matter with outer space, with the rest of the central part of the planet Earth and with its upper atmosphere. With regards to a geological scale of time, the biosphere has stayed in a stationary state and has evolved at the same time. During its development the biosphere has come through various bifurcation periods and has undergone transformations by different mechanisms.

For example, let us examine one of the most large-scale bifurcation biosphere transformations, which took place in the geological past. About 2 billion years ago a so-called Pre-Sinian catastrophe occurred ([89], pp. 27 and 65). Before this catastrophe there existed large-scale 'reducing' forms of life and a huge quantity of pro-bacteria had been living on the surface of seas and land. Their vital functions consisted in reduction of iron oxides. The oxygen was released into the atmosphere and permanently poisoned the reducing environment.

As a result, a dramatic eco-catastrophe took place and 'reducing' forms of life were wiped out. Then, during the next geological period of time, as a result of the oxygen content in the atmosphere, the biosphere started to be self-

organizing in a new way of evolution: an oxidative form of life was spontaneously generated and began its evolution, and still exists today. As is well known, most living organisms live by oxygen consumption and humans are the most important component of the living matter of the biosphere.

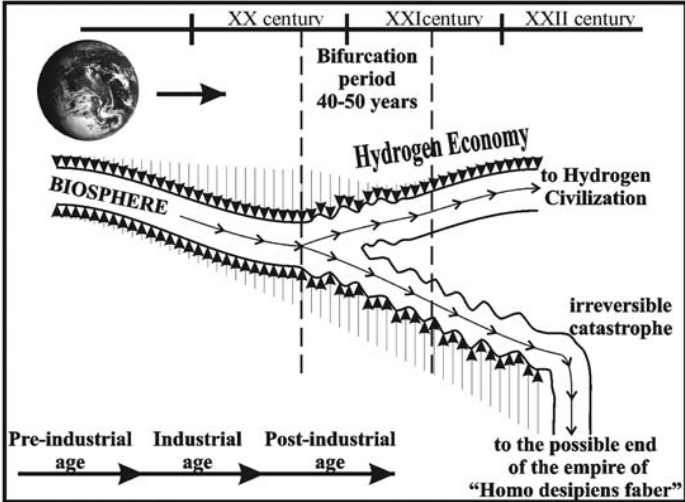
So, from the synergetic viewpoint, it is not surprising that, according to scientific expectations, the evolution of the modern biosphere could be terminated by a new and much more dramatic catastrophe, the result of which would be that the form of Earth life now existing would be wiped out as a result of the actions of ‘*Homo desipiens faber*’.

A diagram of modern and possible future biosphere development showing the current synergetic viewpoints and knowledge is given in Figure 3 [69]. It can be seen that during the transition from the pre-industrial period to an industrial one, biosphere loading, caused according to Vernadsky by ‘*Homo sapiens faber*’ activity, grew permanently and heavily. In the post-industrial period this loading became super heavily polluted and, speaking in images, humans became ‘*Homo desipiens faber*’ [53,54].

According to the evaluations of some scientists [89], in modern times the biosphere has already entered a bifurcation period (or will enter it soon).

By the IAHE HyCi doctrine two ways of biosphere evolution are possible in the future (Figure 3). The first one is the biosphere irreversibly entering a track leading to the catastrophic end of the ‘*Homo desipiens faber*’ empire. The second is a transition of humankind from the hydrogen economy to the hydrogen civilization (Fig. 3). Consideration of this question is of greatest importance, and the main noospheric task for the world scientific community involves a scientific, systemic elaboration of synergetic biosphere evolution scenarios within the nearest 50–100 years.

Figure 3. The scheme of the historical, current and possible future evolution of the Earth biosphere [69].



The situation is dangerous! Indeed, we need to know how much time humanity has before a possible irreversible catastrophe hits the biosphere. So, this point must receive the attention it deserves, and the following HyCi doctrine scenarios of possible biosphere development require urgent consideration and closer examination.

Scenario 1: consider biosphere development for conditions when the amounts of CO₂ and other harmful effluents continue to increase. What will be the impact on the biosphere at different rates of effluent increase for different intervals (in 25, 50, 75, 100 and more years)? Such a global scenario should elaborate on the consequences for all biosphere biogeochemical cycles for all interacting biosphere subsystems, and for humanity and its habitat.

The knowledge of the general laws of synergetics and the possibilities of the existence of bifurcation points provide fundamental ideas for investigations of this kind. From the HyCi doctrine standpoint, it is of prime importance to establish how much time humanity has before the biosphere and ecosystem enter an irreversibly catastrophic phase of development.

Scenario 2: biosphere development when there are realized global and regional programs of a progressive, at first partial, and then complete, replacement of hydrocarbon fuels by hydrogen at different rates of hydrogen energy introduction and for different time intervals (*viz.*, 25, 50, 75, 100 and more years). There has been an initial and encouraging study showing how hydrogen is already being turned to proper use firstly for biosphere conservation, and then for transforming the biosphere into a new state.

It is evident that a movement from hydrogen economy to hydrogen civilization will not only solve the world's environmental problems, but will also produce changes in the biosphere and its functioning over historical and geological scales of time.

Thus forecasting and estimating the future development of the biosphere in various conditions, and the prediction of possible irreversible universal and/or local catastrophes, are tasks of fundamental global importance for human thinking.

6. Public HyCi Ideal: Can It Serve as a Superattractor for the Humankind?

Vladimir I. Vernadsky [1,3–6] distinguished the following types of human thinking: scientific, philosophical, religious and artistic – and he underlined their relative independence, and their deep interrelation and interaction. Many times he had too highly stressed the fundamental importance of mutual influence of different types of thinking on the history line of human thought motion, on scientific worldview change over a human history.

In respect to philosophy Vernadsky wrote: ‘I look at the significance of philosophy for the development of knowledge quite another than the majority of

naturalists...’ ‘Philosophy always comprises *the germs* which sometimes even anticipates the whole areas of a future development of science, and only thanks to a simultaneous work of human mind in such a manner we get a correct picture of inevitably schematic formation of the natural science. In the history of a scientific thought one can clearly and exactly trace such a meaning of philosophy as the *background* and vital atmosphere of scientific thinking’ [6].

On the other hand, advances of the natural sciences influence on philosophical thinking, and in some case – on the formation of new philosophical systems. As was written above, in the 70s of the 20th century there appeared (on the base of physics of complex physical phenomenon and devices) and then started its intensive development an interdisciplinary science – synergetics that describes the development and self-organization of greatly non-equilibrium (in a thermo-dynamic sense of the word), complex, dissipative systems consisting of a large number of subsystems [85–88].

For understanding the logic of this review it is necessary to repeat some main points said above. The ‘synergetic’ systems constantly exchange energy and substance with the outer world. Thanks to this very ‘pumping’ from the outside, their hierarchical self-organization can be maintained for a long time and can exist independently until the so-called bifurcation point (period) is reached. During the bifurcation, a synergetic system is in the highest unstable state. Under the influence of a random, small (fluctuation) influence the system can irreversibly transform into a new state quite different both from the initial and any other possible states.

A crucial thing! The ideas of synergetics and a synergetic way of thinking have quickly penetrated into natural and technical sciences, into biology, geology, archaeology, meteorology, sociology and other sciences. In the 90s of the 20th century, a synergetic way of thinking came into philosophy and history [90,91]. A new trend starts forming in philosophy and a philosophical synergetic picture of a social reality comprising a human being, society, culture and consciousness starts constructing.

At these very years, as outlined above, the world scientific and engineering thinking on the base of Vernadsky’s studies was finding its way into a new understanding of sustainable human future, Hydrogen Civilization.

From the viewpoint of stated above, it’s natural to put a question on a correlation and possible mutual complementarities of a philosophical synergetic concept of the universe and the doctrine of hydrogen civilization. Firstly, let us decide in favour of a very important, and maybe even a central, question of a mutual complementarities of two studies under consideration, namely on a meaning content of one of the main philosophical notions – ‘superattractor’ – and how this notion can be interpreted and highlighted when introduced into the essence of the HyCi doctrine.

Let's first summarize a philosophical matter of the notion 'superattractor' as it is treated in the synergetic concept of the universe [90]. 'Superattractor' is nothing else but a product of realization of an absolute ideal', 'a product of realization of a public ideal'. Then, the sense of history is just a perpetual 'synergetic' motion of a human being to a superattractor. The perpetual motion to the superattractor is therewith of an asymptomatic character of approximating to an 'absolute public product'. Just an asymptomatic character of this motion fills history with an infinitely deep sense, makes its sense *inexhaustible*: 'every time there is reached a stage in the advance towards this product, from its top there is opened up a new panorama full of even more exciting treasures. And a new stage of a perpetual 'synergetic' motion of a human being starts. Since an absolute product can not be practically *reached* within a *finite* historical period, in the mankind's awareness it appears as some spiritual 'sky' that must become a focus of all human efforts'.

Everything stated above fully reflects the style, logics, an integrating character and a finite directivity of a philosophical thinking as such, and at the same time according to Vernadsky (as it was said above): 'philosophy always comprises germs, the latter sometimes surpassing the whole branches of a future development of science ...'

Let's analyze the correlation of the synergetic concept of the universe and the HyCi doctrine and formulate the main questions in the following way:

- Is the ideal of hydrogen civilization, as it is shown in the HyCi doctrine, a result of a public (absolute) ideal realization?
- Can the HyCi doctrine and the very ideal of hydrogen civilization, serve as a superattractor for the mankind?
- How does such a concretized superattractor correspond to its philosophical 'germ' and its philosophical properties? May it be useful for scientific and engineering thinking?

It is the author's opinion that answers on the questions put forward is undoubtedly positive. Really, hydrogen civilization is in a certain sense a 'germ' of the basic idea having its own historical evolution and being quite attractive for the mankind.

In its origins (the 19th century) this basic idea was initiated by J. Verne in a very fantastic manner for that time [7]. It should be emphasized that J. Verne, a famous French fantast-writer, had many scientific forerunners. For example, in 1820 a scientist and engineer W. Cecil in his report submitted to Cambridge philosophical society suggested to use hydrogen as a fuel, and in 1822 he published a scientific article in the journal of this philosophical society 'On use of gaseous hydrogen for creating motive force in machinery'. The first patent on an engine working on the hydrogen-oxygen mixture was granted in England in

1841. In Munich, Germany, in 1852 a court watchmaker H. Teitmann made an engine working for some years on the hydrogen-air mixture. In 1839 an English chemist Sir William Robert Grove created ‘a galvanic gaseous battery’ – a new electro-chemical generator (a fuel cell) that made it possible to obtain electric current with the help of electro-chemical reaction of hydrogen and oxygen. In the first half of the 20th century the scientific and engineering bases of using hydrogen as a fuel were intensively developed.

But that was J. Verne who is by right considered as a herald of hydrogen energy, as it was he who attracted a general attention of a wide reading audience of the last quarter of the 19s and the 20s centuries to a new possibility for the mankind to use hydrogen as fuel; being burnt it gives only water as by-product.

Following V.I. Vernadsky’s idea, one can’t but emphasize that the example given clearly demonstrates the efficiency of a mutual influence of different types of a human thinking: in this case these are scientific thinking and artistic one.

As stated in the introduction, in the second half of the 20th century J. Verne’s great idea was revived on a new level as a very brave scientific and engineering hypothesis and then like a technical practice (hydrogen energy – hydrogen economy). In the beginning of the 21st century an outstanding hydrogen idea of J. Verne got its completeness in the doctrine of hydrogen civilization of the future. So, in the HyCi doctrine there is laid the groundwork for a great human ideal, passed through its historical evolution, to save the Earth biosphere favourable for the life by implementing the movement of mankind along the ecologically clean vector ‘Hydrogen energy → Hydrogen economy → Hydrogen civilization’.

Obviously, hydrogen civilization both in its conceptual essence and by its accomplished historical maturity, by its attractivity as a public ideal can (and will) perfectly serve as a superattractor striving for which will fill the forthcoming history of the mankind with a new sense.

In accordance with the philosophical concept of the synergetic universe an advance to this defined by a scientific thought specific superattractor will have an asymptotic character of approximating to an ‘absolute product’. In this perpetual motion, from the top of every completed stage of evolution ‘there is opened a new panorama full of even more exciting treasures, and a new stage begins’ [90]. This philosophical statement will undoubtedly serve as a ‘germ’ of a further intensification of the HyCi doctrine development. Here, a new work of a scientific thought will be need and, first of all, in the direction discussed below.

Really, today we can define at least *two historical stages (two phases) in the asymptotic motion of the mankind to hydrogen civilization as a super-attractor*. According to the HyCi doctrine, at the first initial stage biosphere will enter into “the epoch of its renaissance”, and the ecological conditions of the

mankind existence will be saved and even improved to some extent. At this stage, to produce hydrogen the mankind will use still *non-renewable and some alternative* sources of primary energy: atomic energy, fossil fuels, biomass, waste and in the future – thermonuclear energy. So, this historical stage the humankind will use a combination of energy carriers: hydrogen, electricity, bio-, fossil- and waste fuels, and maybe some other hydrogen containing energy carriers. And for every next period of time there will be found the potential of optimal options to the market simultaneously reaching the best economic results.

The use of *renewable* sources of energy of the sun and its derivatives at this stage will take place but in a limited scope (by economic-technical reasons only 10–20% of the total power consumption). It's quite clearly, that the very idea of a possibility of a favourable development of biosphere at the first stage of moving to hydrogen civilization is just a 'spiritual sky' for the human awareness of our time (when they think more, and quite soundly, about a world ecological and climate catastrophe).

On reaching this stage in the asymptotic motion to the superattractor, according to the synergetic concept of the universe, 'a new exciting panorama will open and a new historic stage will begin'. Within the HyCi doctrine they think that the evolution of this following historical stage will be initiated and supported by more and more wide *direct use of the sun energy* (and its derivatives) when producing hydrogen for energy life-support of the mankind. It's evident that at this historically distant stage, biosphere will undergo the transformations, the analogues of which biosphere didn't have in its geological and historical past.

Let us cite only one example. Elementary calculations show that if the Sahara surface is covered with semi-conductor solar batteries, then the energy obtained will be enough to provide the life-support of the whole mankind. On the other hand, realization of the projects of such a scale (this is the work for a 'superman' and 'supermankind' [90]) will inevitably change a fixed power balance of biosphere with all subsequent hardly predictable consequences. As it follows from V.I. Vernadsky's studies, such power transformation of biosphere 'will move' a geological existence of the Earth, biosphere and the mankind as the main geological force.

So, at this new historical stage there will come forward the problems of forming a renovated superattractor. And it will be accepted by the mankind as 'a product of realization of a new absolute ideal'. A philosophical thinking therewith gives us the following picture: '...for forming this ideal people will possess gigantic possibilities of transforming the outward things and themselves. And from all the possibilities people will choose those *that will be in a good agreement with the ethic and esthetic norms imposed by absolute morals and absolute beauty*' [90].

Concluding this chapter of the work, let's repeat that philosophical sense of history is just in the process of the permanent synergetic human motion to super-attractor. The HyCi doctrine and future transition into the era of hydrogen civilization fill this philosophical paradigm (this spiritual 'sky') with a specific practical content. At the same time, it's evident that under the influence of philosophy the main points of the HyCi doctrine will be more generally comprehended later.

From above discussed an important logical consequence attracts attention: philosophy of sustainable human future, Hydrogen Civilization, should be systematically elaborated.

7. On Philosophy of Hydrogen Civilization

A necessity and importance of a philosophical comprehension of every aspect of the HyCi doctrine within the modern philosophical systems gives rise to no doubt. But the question can and must be put in a greatly important way: 'Can philosophy of HyCi future be a subject of a novel independent philosophy system (of course not isolated from other parts of philosophy but with a definite degree of separation as a generalizing advanced philosophical study)?'

The main subject of philosophy depends on a time in its historical aspect and is determined by the most difficult governing problems which the people of each historical epoch must solve. These difficulties are of such a scale and complexity that they require all mental powers of the mankind [92].

Collingwood [92] illustrates this proposition with the below stages of the historical evolution of philosophy from the Ancient Greece times till the 19th century.

In Ancient Greece (the 4th century B.C.) a main scientific task was creating mathematics bases and a Greek thought put mathematics into the centre of its philosophical scheme. Working out the problem of knowledge, the Greek philosophy therewith meant mathematical knowledge, first of all.

In the Middle Ages the European philosophical thinking run into theology problems, and a philosophy range of problems originated from the thoughts having to clean up the relations between God and a human being.

In 16–19 centuries the European philosophical thinking was mainly aimed at laying the foundation of natural sciences [6,93]. Since Francis Bacon and René Descartes (*Renatus Cartesius*) such an orientation of thinking has prevailed in all branches of philosophy.

Now let us put a question having its origins in Collingwood's thoughts formulated above. What is the nowadays main, governing human problem, which requires all mental powers of mankind to be solved? Without any doubt in the 21st century such a main, governing human problem is in existence: humanity can preclude world ecological catastrophe and conserve the

biosphere's ability to sustain the human life. In essence the point of the matter of the 21st century is to build up a sustainable human being. And by the hard opinion [2] of the World Hydrogen Community the sustainability of the human future being might be building up only by movement along the vector '*Hydrogen Energy → Hydrogen Economy → Hydrogen Civilization*'.

Being formulated so radically, the question becomes an essentially new, fundamental question for the up-to-date philosophical thought. The author will outline only some principal peculiarities of a new philosophy subject – the hydrogen civilization philosophy. The author's aim herewith is to attract attention of the modern philosophical community to this problem. So, let us raise some points of principle of the above outlined problem.

It is not an easy task to perceive the basic Collingwood's ideas. And I'll repeat that every historical epoch has the subject of philosophy specified by the most important problems needed to solve, problems, which people have to overcome only with the greatest difficulties. Let us ask a question in this way: is a nowadays human thinking faced with the task of such a scale? The answer is unique: it is. That is true that a human being of the 21st century really faces a grand problem which is vividly reflected in a necessity to solve a very difficult dilemma:

- either to keep up through inertia the traditions of the 20th century in the sphere of thought and objective reality and doing so to find oneself in the homestretch of the human civilization;
- or to direct the energies of one's thought and activity to speed up the mankind transformation to the era of environmentally appropriate sustainable hydrogen civilization.

It's clear that all efforts and energies of a human thought and practice should (and will) be concentrated and directed at a positive solution of this dilemma. A natural conclusion follows from the above: the doctrine of hydrogen civilization future as a scheme of a modern scientific and technical thought and a very feasible reality of a new epoch in a historical future are well-deserved to be a subject-matter of a special branch of philosophy – philosophy of hydrogen civilization.

The subject-matter of hydrogen civilization philosophy mentioned above is a very specific one for a modern philosophical thought. So, there are good reasons to raise a question: either the modern philosophy methodology is sufficient enough to solve tasks of the hydrogen civilization philosophy or new methodological principles have to be approved.

Let us explain that a statement of such a question is rendered lawful. We would remind that in the 16th century a new natural science started an efficient development [6,93]. There appeared a necessity to lay the foundation for natural sciences and that initiated and gave rise to the development of a new philosophy

and its different trends. Hereinafter let us refer to the philosophy of the 16–19th centuries as philosophy of natural sciences and a corresponding thinking – as a natural sciences thinking. Development of philosophy along this direction resulted in the appearance and establishment of Francis Bacon and René Descartes’ methodology, in its permanent development and improvement and in some cases – in its illegal dissemination to other branches of knowledge [6,93].

The main peculiarity of the natural sciences methodology, as known, means that cognition of the external world (the object of cognition) and hypotheses of a human thought which learns it (the subject of cognition) are implemented *through observing and making experiments at present*. Either the results of natural-scientific cognition are true (or false) can be validated experimentally or practically later in any future point of time.

The object of cognition of the hydrogen civilization philosophy and the work of a reflexive mind studying it on principle differ from those of natural science philosophy. Really, comprehension of the future is in the centre of the hydrogen civilization philosophy scheme. But the future is only to be, and hypotheses on its formation and development which appear in a reflexive mind can not be verified nowadays in the same way as natural-scientific hypotheses are controlled.

The above make us doubt about a possibility of using (in full measure or by separate problems) the methodology of natural science philosophy to help solving cognition problems of the hydrogen civilization philosophy. Just in the same way there can be raised a question of either the use of the methodology of other branches of philosophy, in particular the modern philosophy of science and technology, is justifiable in the hydrogen civilization philosophy.

It should be too highly underlined that the philosophy of the hydrogen civilization future, being devised by a philosophizing mind at the present, will introduce, as can be expected, some new elements into the theory of cognition. And it will serve as a philosophical basis of the theory of sustainable historical movement of the mankind into the era of hydrogen civilization.

8. Humanitarian–Cultural Groundwork and Legislative–Economical Mechanism of the HyCi Transition

A historical task of the HyCi doctrine in its humanitarian-cultural aspect consists in forming an elitist and mass hydrogen–ecological and noospheric consciousness in separate leader-countries, and then in the whole world.

Just the humanitarian–cultural formation of the elitist and mass hydrogen–ecological consciousness will allow:

- To approve necessary international legal norms regulating the order of solving inevitable geopolitical and geo-economical

problems and to develop pattern laws (recommended as a specimen for national parliaments and governments), regulating the ways and perspectives of passing into hydrogen civilization.

- To adopt national laws regulating the legal and financial guaranteeing of using the power hydrogen, defining the ways and trends of the state financial support and mechanisms of attracting private capital to establish a competitive market of the power hydrogen *etc.*
- To provide a legislative–economical mechanism of HyCi transition to be functional.

This new hydrogen–ecological comprehension of the mankind elite cannot be based on the idea of prohibiting an expansion of energy consumption ‘in the manner of Kyoto Protocol’. It must be and will be based on the real, permanently adjustable results of the system predictive and analytical computer added study of biosphere functioning as a whole (and its separate systems) for the next 50–100 years by the scenarios taking into account the ways and scope of using power hydrogen in the world industry, transport, in private life.

Now, let’s pay attention to hydrogen–ecological *mass* consciousness. Really, its consecutive formation and degree of evolution will finally determine either the mankind will adopt (or will not) the motion into the era of hydrogen civilization.

A historical necessity of changing the mass consciousness when passing into the era of the ecologically clean hydrogen civilization is determined by the following.

Economy of the 20th century was based on a permanent initiation of the growth of human needs in ‘things and services’. The consumption of more and more quantity of ‘things and services’ was and is considered to be an equivalent of a high *quality* of the life.

Progressively increasing production ↔ outrunning consumption (demands) is the 20th century central economic dilemma, which still determines life nowadays. Correspondingly, *to have more ‘things and services’ is a modern paradigm of the life.*

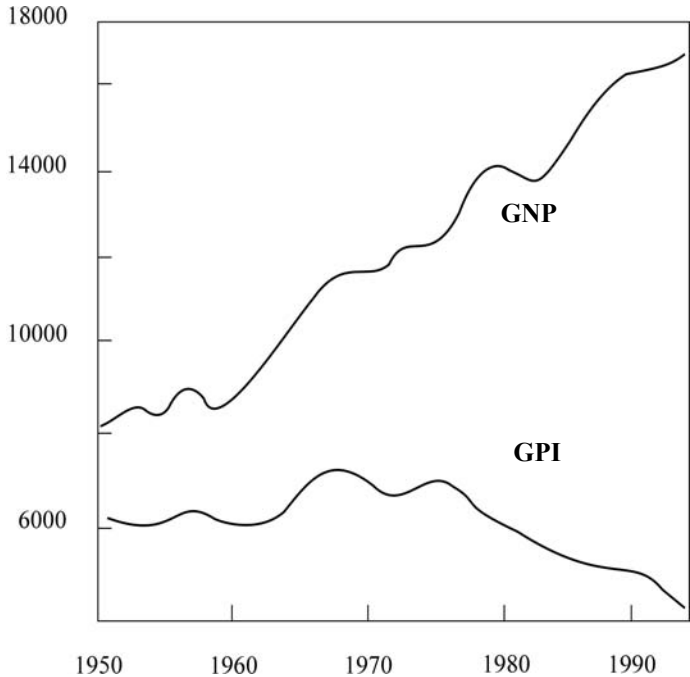
However, during the last decades the integral indications of the real life quality gradually reduced more and more. The World Health Organization (WHO) data shows that 6% of all deaths are the direct result of environmental pollution.

Independent experts come to a unique conclusion on unfavourable tendencies in the development of modern economy and modern society. It’s necessary to understand here that the gross domestic product (GDP) or the gross national product (GNP) fix not only the *increase* in useful production, but

include the *harmful* for the society activity of *human*, for example, gambling industry, porno-business and other businesses serving negative *Homo desipiens* demands. V.A. Zubakov [91] formulated that the GNP shows the market dynamics only – the more demands, the higher GNP.

A new more complicated and complex ‘index of a real progress (IRP) is a Genuine Progress index (GPI)’, suggested by K. Cobb in 1989 (see in [91]), including more than 20 indicators of the environment, health, education and state of natural resources, and giving quite another evaluation of the modern social and ecological situation. Really, for example, in the USA (Fig. 4) over the period of 1950–1995, the GNP per capita grew more than twice, while the IRP over the period since 1975 till 1995 decreased by 45%.

Figure 4. A historical tendency of changing life conditions in the USA. (from the Report of Worldwatch Institute).



The situation will be undoubtedly deteriorated (see Appendix 1). That means that in 21st century the working paradigm of the life quality must be replaced by a new one.

According to the HyCi doctrine, in the 21st century the mankind will adopt *a new humanitarian–cultural paradigm: a high quality of life will be associated (and accepted) as an optimum combination of good, ecologically clean environments, habitat (first of all) with a reasonable satisfaction of necessary spiritual and material demands. Based on this paradigm, a new mass comprehension will serve as humanitarian–cultural basis for a legislative–economical mechanism of transition to hydrogen civilization.*

The above said is a decisive humanitarian and cultural condition facilitating a real motion of the mankind to the era of hydrogen civilization. So, let's formulate and discuss the main regulations of the legislative–economical mechanism of the transition to the first stage of hydrogen civilization, paying attention to the humanitarian–cultural basis of functioning of this mechanism.

Let's put a question in the way: what in future will define the attainment of an economical benefit of producing and using power hydrogen? In other words, will or won't power hydrogen be acceptable in future, will or won't it be in wide demand later as a good of the world market economy?

The answer on this fundamental question is given in the HyCi doctrine that formulates three base regulations of the legislative–economical mechanism of the formation of the hydrogen power market.

The first base regulation. Technical improvement of hydrogen equipment and hydrogen power technologies (that is successfully proceeding for more than 30 years) will permanently decrease the cost gap between a relatively expensive for the time being hydrogen economy and the economy of oil and gas. This tendency is now quite well observed when analyzing the evolution of hydrogen energy and hydrogen economy at the end of the 20th century and the beginning of the 21st century.

The second base regulation is based on the exhaustibility of the world resources of oil and gas. As early as the 70s of the 20th century this factor was considered already as one of the main reasons calling for a transition to hydrogen energy (to atomic–hydrogen energy in the USSR). At the beginning of the 21st century this problem arose in a rather critical form and it already dictates negative geopolitical tendencies and decisions. In a foreseeable future (~30s of the 21st century) the world economy will begin to experience a real and always increasing deficit of the natural energy resources, first of all oil and gas. In this connection, a modern tendency of instability and increase of prices on oil and gas taking place in the world economy in the near future will take a stable uniform character of only a permanent growth of prices. It's quite clear that such a line of development of the world market of energy carriers will facilitate the cutting down of a cost gap between hydrogen economy and oil and gas economy.

These two base regulations themselves will stably guarantee the motion to attain an economical benefit of power hydrogen and in a historically foreseeable future will guarantee a stable self-development of the hydrogen market economy. But an important condition of this historical process being stable is to accept by mass awareness new market products: hydrogen automobiles, hydrogen filling stations and other products of hydrogen engineering and hydrogen power technologies. In essence the motion in this direction has already begun: here, one can mention international efforts to organize demonstrational

hydrogen filling stations, demonstrational hydrogen automobiles *etc.* It is already in 2004, the participants of the 15th World Hydrogen Energy conference in Yokohama could take part in the trial runs of hydrogen automobiles and buses. The next international hydrogen conferences and exhibitions fixed this tendency. Detailed information on this question can be now found in Internet and in the public press.

The third base regulation. It is first of all based on the indisputable situation that as was said above, the modern state of biosphere causes the most serious apprehensions and there is put a question about the system crisis of the current civilization, about a potentiality of the mankind self-destruction.

Really, the 20th century human activity led to the global ecological crisis in all possible directions. In addition to aforesaid it can be too highly stressed that pollution of the environment, *viz.* air, water, soil all over the world, has reached a global point. And along this line trans-borders pollutants transfer plays a great role. So, pollutants are spreading over thousands of kilometers from their sources. For examples, chemical toxins have been already found even in ice of the Antarctic. Therefore, human poisoning by heavy metals, radioactive elements and chemical toxins takes place all over the world. I point only 2 examples. Lead, a car pollutant, leads to degradation of human brain. Dioxin, a chemical production pollutant, is much more strong poison than potassium cyanide.

Such direction of civilization development and reality of the 21st century total biosphere catastrophe has been a subject of a great anxiety of the leading representatives of the world scientific and cultural community during last decades. And there have been published a lot of very deep analytical investigations on the above negative problems. It is demonstrated (predicted) that in the middle of 21st century toxin onset might be very rapid, non-reversible, avalanche similar. And total genetic mutation of the humanity would take place.

There are impossible to give references and to name the authors even of the main publications. I'll indicate only the most comprehensive investigations of a great scientist, Professor V.A. Zubakov, a founder of a new science 'historical geocology' [89,91]. Readers of this review can communicate with Professor Zubakov by e-mail: inenco@mail.neva.ru.

The author's of this work conviction is the same. Shakespeare's Hamlet question sounds now on a global scale: 'To be, or not to be *the humankind*: that is the question'.

Additional information on the 21st century total biosphere catastrophe readers can find in the Appendix 1.

The HyCi doctrine in its humanitarian and cultural basis reflects a real situation that *the mass consciousness of the mankind and the elitist*

comprehension of a significant (even larger) part of the educated society do not perceive, do not comprehend:

- permanent deterioration of the life quality of the ‘golden billion’ even (not only the whole mankind);
- a historically near danger of the total biosphere catastrophe (not only the world ecology and climate crisis). Let us remind once again that the humankind is an integral part of the biosphere.

What needs to be done by the humankind to avoid such a future? Answering this question, the HyCi doctrine takes as its basis the slogan of the market economy: ‘Everything must be paid for!’ and makes it wider: ‘Everything and ***the life on the Earth too***, must be paid for!’

The HyCi doctrine asserts that a historical time interval needed to reach the first stage of hydrogen civilization when the mankind can already avoid a world-wide ecological catastrophe and save biosphere acceptable for living can and must be fundamentally shortened. That can and will be attained ***by changing the paradigm of the life quality and by introducing the system of ecological taxes***.

A possibility of introducing ecological taxes will therewith be fully specified by mass hydrogen–ecological consciousness and, as a whole, by humanitarian–cultural readiness of the population of industrial megalopolises, separate countries, groups of countries, and, at last, by the readiness on a global scale.

So, in addition to two base regulations given above, just the system use of ecological taxes as the most important constituent of the more fast transition to hydrogen civilization will be fully based on an obligatory move of the elitist and mass awareness on the hydrogen–ecological path (introducing the system of ecological taxes). Underline once more, the HyCi doctrine asserts that rate of creating the humanitarian-cultural basis will on the whole specify the rate of movement of the mankind by the ecologically clean vector “Hydrogen energy → Hydrogen economy → Hydrogen civilization”.

The above given three base regulations provide a groundwork of the legislative–economical mechanism of the more fast HyCi-transition that, functioning (by Vernadsky) as a noospheric necessity, will ensure the world hydrogen economy to enter into the economically profitable status and to serve as a technical–economical basis of the mankind transition into the era of hydrogen civilization.

Now, let’s point the spheres that, according to the HyCi doctrine, will be embraced by the future humanitarian–cultural transformation:

- the spheres of human activity forming the mass awareness:
 - • education and upbringing (from the children's preschool till higher and post-university education);

- the mass-media (newspapers, popular editions, radio, television *etc.*) and new ones forming informational society (Internet and other new electronic mass-media);
- fiction, cinema and other arts;
- other ways and means of influencing the mass awareness;
- the spheres of human activity forming the elitist awareness:
 - Vernadsky's biosphere and noosphere doctrine in its historical status and nowadays development;
 - the current geo-ecological studies (including historical geoecology, ecological studies on particular problems *etc.*);
 - philosophy (including a synergetic concept of the universe and synergetic philosophy of history);
 - history (including the history of science and engineering, the concept of synergetic historical method *etc.*), culturology, sociology, political science *etc.*;
 - economical and socio-economical sciences;
 - natural and engineering sciences;

According to V.I. Vernadsky's logic, one should establish that the motion of such a scope must be and will be really noospheric, and the historical process of forming and taking a new hydrogen–ecological comprehension will capture (in one way or another) the larger part of the world elite: scientific, cultural, administrative, financial, legislative *etc.*

Let's now consider the question about a leader. Just the world hydrogen movement that appeared more than 30 years ago thanks to the enthusiasm of “hydrogen romantics” in the West and in the USSR, now has quite a weighty position in the world and in the leading industrially-developed countries.

According to the HyCi doctrine, the World Hydrogen Movement should play a catalyst role in the theory elaboration and practical realization of hydrogen civilization. One should pay attention here to the following important circumstance. An overwhelming majority of the world hydrogen movement are hitherto the representatives of the scientific and engineering elite. In the last years it was joined by the most active part of the industrial–corporative and administrative (international and national) elite. An important conclusion follows that at the present historical stage just the scientific and engineering elite should take upon themselves (strange as it may seem) the role of a leader in working out and realizing the humanitarian–cultural basis, the theory and practice of the mankind transition into the era of hydrogen civilization. Therewith specialists of humanitarian–social sciences, mass-media, education *etc.* must be winned over for a team-work for the sustainable human future, Hydrogen Civilization.

The further development and realization of the HyCi doctrine will undoubtedly get a noospheric character and will want the efforts of the world wide scientific and cultural community. In this historical process special role will belong to the formation and a permanent deepening of a new hydrogen–ecological elitist and mass comprehension first in industrial megalopolises and leader-countries, and then on a global scope as a whole.

9. Inevitability of Geopolitical Contradictions – an Attendant Problem of Transition to a Hydrogen Civilization

Let us consider now the geopolitical – internationally legislative component part of the IAHE HyCi doctrine. In this regard, the concept is based on the incontestable proposition that historical transformation of such a scale like ‘humankind transition to the hydrogen civilization era’ will permanently pose changes in the world geopolitical situation. Therefore, in the HyCi doctrine there are at least some large-scale factors which would play the role of driving forces behind the geopolitical changes, and these factors would affect the fundamentals of existence in the life of particular states (groups of states).

The first one arises from *the inadequate perception of various states of the world environmental catastrophe jeopardy*. Really, even short-term, ‘soft’ methods of solving these problems contain the principal geopolitical antagonisms. For example, world community efforts to realize the Kyoto agreement (1997) clearly demonstrate this fact. Thanks first of all to Japan, Europe and Russia, the Kyoto agreement came into force. However, such an approach turned out to be unacceptable for the strongest world economies of the USA (pointed out already in [57]), for the actively growing economies of China, India and some other countries, which aim at future world domination.

It is unlikely that such an approach will satisfy poor countries for which the prohibition to increase energy consumption amount to a requirement to live in perpetual poverty. The HyCi doctrine does not undermine the Kyoto agreement. At the same time the HyCi doctrine shows the primary source of its restriction that generates geopolitical-scale intergovernmental contradictions. The restriction of the Kyoto agreement is conditioned by complex reasons [57]: geopolitical, economic, technical, scientific, etc., but the main reason is that the plan was *to solve a very complicated and complex worldwide environmental problem by a simple and short-term method of attack*, namely, by a basic undertaking of some obligations by countries, in the form of quotas, to reduce harmful emission into the atmosphere.

To put it precisely, any attempt to resolve the greenhouse effect and to avert a world environmental disaster by restricting energy consumption and by freezing economic growth will have no prospects of success. It is pertinent to note that already Vernadsky stressed that any call for a return to a primitive life

(such calls, both in a direct and veiled or mild form, were always put forward) is not well-grounded and cannot be realized in practice. Such an idea, speaking figuratively, is a 'still-born' idea.

Amplifying this, we can say (leaning upon Vernadsky's thought) that a 'Forward to primitive existence!' slogan is inconvenient to the human race. Therefore, let us repeat: the lines of attack for solving the biospheric problems 'a la Kyoto agreement' will always serve as a basis for geopolitical antagonism.

Now, let us point toward another large-scale factor, namely, the limitation of world oil and gas resources. Oil and gas are the basis for the modern world economy and will be the most important energy sources during a prolonged change-over period of transition to a hydrogen economy and to hydrogen civilization. But, nowadays in the beginning of the 21st century, the world oil and gas problem has become an extraordinarily pressing one. For example, the specialists' estimations show that the world's proved reserves of oil do not compensate for the increase in oil consumption. This problem provokes already negative geopolitical decisions. Therefore, energy security is beginning to dictate to some countries the necessity of a rapid 'transition to hydrogen' (the USA – the 'hydrogen security' politics).

So, transition to a hydrogen economy and then to a hydrogen civilization will undoubtedly be accompanied by permanent global and/or local geopolitical and geoeconomical contradictions. In particular, changes in the national interests of many countries will take place – 'old' and 'new' energy resource owners, changes of geoeconomical interests of transnational energy companies. A polarity reversal might arise in the sphere of geopolitical and geoeconomical attractions and the like.

It's obvious from the above that drastic changes are to take place in the international political life in the spheres relating to a possible world-wide ecological disaster. Here, we should refer to history again, to the short-range history this time.

Really, in the first half of the 80s of the 20th century in the USSR there was observed the first large-scale computer tests carried out on the model 'Gaea' (in the Ancient Greece mythology *Gaea* was goddess of Earth) in the computer centre of the Academy of Sciences of the USSR supervised by academician N.N. Moiseyev [94]. Large model calculations aimed at estimating climate changes on Earth, including those caused by a nuclear catastrophe. In Germany in the past 70s Professor P. Crutzen (Max Plank Physico-Chemical Institute) [95], and later many scientists in different countries showed that a nuclear explosion would act as a match which would provoke a fire of an unprecedented force. As a consequence, a lot of soot will hang over cities and towns (and not only over them) as a result of atomic bombing.

Another step was made by Professor K. Sagan and his colleagues of Cornell University (the USA) [96]. According to Sagan's scenario, in which P. Crutzen's data were used, Earth's vast territory will be covered with lightproof soot clouds in the first hours of the war. Soon these scientists' estimates were published in magazines (first, not in scientific journals) and gave rise to the fundamental notions 'nuclear night' and as the night would cause the cold, there will be all world 'nuclear winter'.

Professor Sagan's calculations were immediately processed with the mathematical model '*Gaea*' in the USSR [93]. The results proved to be astonishing: 'a nuclear conflict will lead not to a local fall of temperature and darkness under separate soot clouds, but to a global nuclear night' which will last for about a year or longer. Nobody will be able to go through this nightmare, no matter where he will live – in America, Europe or on the South Pole'. These conclusions are a result of joint effort of a large international group of scientists working in parallel and independently in different countries: FRG, the USA, the USSR (on the details of the problem based on the computer calculation and computer-aided research see [97]).

Summary: a global disaster of the biosphere and extinction of the mankind are possible and not as a result of a natural phenomenon but as a hand-made work (it will be enough to press a button!)

The above said on a global nuclear night was comprehended and discussed at the international level on October 31–November 1, 1983 at the World Congress 'The World after a Nuclear War'. What is especially important from the viewpoint of this work? Right after the Congress completion (!) it proved to be politically possible to organize a television space bridge between Washington and Moscow. It's worth reminding that it was the time of a cold war. But consent to carry on the television space bridge between two opposing countries – the USA and the USSR – was achieved. The hall in 'Sheraton' hotel in Washington was connected with the hall of the TV centre in Ostankino (Moscow) through the TV-net, and every participant of the television space bridge (scientists, politicians etc.) could put any question to the opposite side.

At the end of the television space bridge program the soviet side gave such estimation: '...nuclear weapon is no more an instrument of politics and even not an instrument of war. That is an instrument of self-killing' (Academician E.P. Velikhov) [94].

The historical event described above is a pattern and serves a good example for solving up-to-date ecology and biosphere problems, which face the humankind, for searching scientific and political ways of forewarning about an approaching world-wide ecological disaster.

I mean to tell again. On the viewpoint of the author of this article the historical precedent described above is to be a pattern for solving scientific and

political (and other) problems which will inevitably arise in the near future in the transition stage to the hydrogen civilization era.

According to the IAHE HyCi doctrine, the above HyCi problems are just around the corner and thought needs to be given to work under legislative (not by force) governing of possible negative tendencies on the road to hydrogen civilization.

10. Perceived Noosphere Self-Organization of Movement on the Historical Track: ‘Hydrogen Energy→Hydrogen Economy→Hydrogen Civilization’ (preliminary viewing)

As indicated above, the noosphere, according to Vernadsky [4,5], is a special stage of biosphere development when a dominant driving force of its self-development is science, with human intellectual activity as a general planetary phenomenon. Following the spirit of Vernadsky’s doctrine it is possible to say that transition to the hydrogen civilization era will inevitably occur as a result of a natural biogeological phenomenon. This transition will be realized by the noosphere self-organization conditioned by the human intellectual activity. A transition of such scope and significance cannot be realized over a short period. However, it will be realized by humanity in the historical period of its rational activity.

The HyCi doctrine formulates the stages (main points) on the way to the era of hydrogen civilization that will be put into operation in the 21st century. Let us generalize some of these stages, *which may take place successively and/or concurrently*. Where and when it is necessary, let us stress noospheric character of the required humankind’s activity and self-organization.

- The stage of a systemic computer added study of changes of the biosphere, its sub-systems and, in particular, the Earth’s ecosystem, which (being induced by humanity) is as a result of change-over (or not changing-over) to a new energy carrier – hydrogen. This stage is noospheric indeed, and an important segment of the world scientific community will take part in it. The germ of such a community is already in existence in the form of the world hydrogen movement and the environmental community of analysts, who are studying the greenhouse effect, its disastrous environmental, economical, political and other impacts.

The integration of efforts by these scientific communities is a modern task. Scientific results available at this stage have to provide the humanity with real, highly plausible, accurate, comparative and predictive estimates of biospheric,

environmental and other consequences of a wider use of energy carriers in question, i.e. fossil fuels, biomass, hydrogen and others.

- The stage of formation of a new environmental and noospheric consciousness of the general public of all the countries. This new consciousness (intellection) cannot be based, figuratively speaking, on the idea of ‘moving ahead to the primitive living’ by putting vetoes on energy consumption. This new consciousness will be based on scientific and highly reliable predictions about the manner and rates of humanity’s change-over to the environmentally clean energy carrier, hydrogen. It is very important that the current world hydrogen scientific community permanently pays great attention to this ‘unscientific’ but absolutely necessary activity, without which a transition to hydrogen civilization is impossible.

The role of the general public of highly industrialized countries is especially important, because most of the world’s science is concentrated in these countries, and at the same time these countries pollute the environment most. It is obvious that humanity has a right to expect, from these countries, the largest intellectual and financial contributions to enable transition to environmentally friendly hydrogen civilization. The general public in both the countries of transforming economics and in the developing countries has to be fully involved in this process. In accordance with the HyCi doctrine, just a new mass consciousness will serve as a basis for acceptance and successful functioning of the legislative–economical mechanism, which will supply a realistic possibility of transition to the hydrogen civilization era.

- The stage of an official consideration of the prognosis and perspectives of transition to an era of hydrogen civilization by the international organizations (first of all by the UN and its substructures) and by the regional political and economics organizations. At this stage, the international legislative standards regulating the procedure needed to solve geopolitical, geoeconomical, regional political and economical problems will be elaborated and accepted. The framework laws (recommended to the national parliaments and governments), which would outline scientifically and economically founded ways and mechanisms for the transition to hydrogen civilization would also

be accepted. The work at this stage may lead to more effective international cooperation.

- The stage of consideration by the parliaments of the framework laws and recommendations suggested by the international and regional organizations as to the transition to hydrogen civilization regarding specific conditions of individual countries. The living standards of each country and its economic state, scientific potential and environment and so on, should all be considered. The designing and adoption of laws should follow for the regulation of financing and the establishment of comprehensively organized national enterprises, which would encourage the use of hydrogen, investment of private capital and the establishment of a competitive market for hydrogen energy.
- The stage (historically this will be a prolonged stage) of a scientifically, legislatively and economically ensured transition to hydrogen civilization. According to the HyCi doctrine, in the beginning of this long stage *the legislative–economic mechanism* of transition to hydrogen civilization will be elaborated in detail and will enter into ‘the play’ like a noospheric rule. Historical necessity and the main principles of this mechanism of transition to the era of environmentally friendly hydrogen civilization were discussed above.

According to the HyCi doctrine, I shall repeat, in the 21st century humanity will assume a new paradigm: a high quality of life will be associated (and perceived) as an optimal combination of a good, ecologically friendly human environment (habitat) with a rational satisfaction of necessary life needs. Established on this paradigm a new mass consciousness will serve as a humanitarian–cultural basis for a legislative–economical mechanism of transition to hydrogen civilization. On these grounds, international organizations will accept and pass in national parliaments, the international legislative standards and corresponding framework laws recommending ecological taxes to be put to use.

Under these conditions some ecologically active countries with suitable humanitarian–cultural and economical conditions will pass national laws regulating the transition to hydrogen civilization. These countries will initially implement light ecological taxes. Then, gradually they will enforce increasingly high ecological taxes for using fossil fuels and polluting technologies. Along with aforesaid hydrogen technologies will be steadily improved on one hand, while on the other hand, because of the limitation of the world resources, the price of oil and gas will continue to go up. All the above factors will make the

production of hydrogen energy and its increasingly wide use in transport, industry, private life etc., to be profitable. According to the HyCi doctrine, this is a matter of a legislative–economical mechanism, which will guarantee success in progression along the vector ‘Hydrogen Energy → Hydrogen Economy → Hydrogen Civilization’.

The doctrine affirms that the prolonged nature of the transition means that HyCi will spread in an uneven, fragmented manner in geographical and geopolitical spaces, in humanitarian–cultural and industrial–ecological spheres, in separate branches of engineering and technology, production and so on. This feature of the HyCi doctrine is subject to future comprehensive elaboration. One fundamental point is detailed further below.

It is well known that industrial megalopolises play an extremely important role in modern economics. However, they are very adverse habitats. With imagination, industrial megalopolises might be denoted as being the ecological black holes of the biosphere. Really, they permanently draw in to themselves the manpower and material resources of the planet and cause great ecological problems. But, space black holes do not put out even light (photons), whereas the ecological “black holes” are characterized by permanent and intensive emission of non-environmental pollutants into the biosphere.

According to the IAHE HyCi doctrine, the ecologically load-carrying megalopolises, such as California in the USA, Ruhr in Germany, Donbass in Ukraine, Moscow, Ural and Kuznetsk regions in Russia, Shenyang region in China, will have to play a leading role in the transition to the hydrogen civilization era. Without any doubt in historically soon period just some large megalopolises might be the first regions of the earth jeopardized to be collapsed in themselves under the force of their own anti-ecological superactivity. And a threat of collapse will force them to realize the legislative–economical mechanism of HyCi transition.

At the same time the megalopolises will provide good examples and experimental fields for their own countries and for all humanity in the efforts focused on sustainable development and a sustainable future.

11. The Present State of International HyCi Affairs

At present hydrogen energy is already in the sphere of patronage of United Nations Organization (UN). From the very beginning it was initiative of IAHE and a long international work of the IAHE President T.N. Veziroğlu. In 2003 the United Nations Organization had settled the question and UNIDO had been charged with a mission to establish the International Centre for Hydrogen Energy Technologies with the general aim to assist the interrelation between rich north countries and developing south countries in the sphere of hydrogen energy technologies.

An international Centre for Hydrogen Energy Technologies (UNIDO-ICHET) had been established in Istanbul by the agreement between UNIDO and the Turkish Government in October 21, 2003. Since May 21, 2004 the UNIDO-ICHET (founding Director T.N. Veziroğlu) is functioning rather successfully [98,99]. Hydrogen energy has been developing now very intensively in Argentina, Brazil, India, China and in many other developing countries (a new Director of UNIDO-ICHET is Professor E. Türe).

During the first years of the 21st century in all the countries, participants of the world hydrogen movement, national associations of hydrogen energy have been formed and working actively.

In 2003 the International Partnership for the Hydrogen Economy (IPHE) was established in Washington as an international institution to accelerate the transition to a hydrogen economy. Each of the following IPHE partner countries has committed to accelerate the development of hydrogen and fuel cell technologies to improve the security of their energy supply, environment, and economy: Australia, Brazil, Canada, China, European Commission, France, Germany, Iceland, India, Italy, Japan, Republic of Korea, New Zealand, Norway, Russian Federation, United Kingdom, United States.

The IPHE provides a mechanism for partners to organize, coordinate and implement effective, efficient, and focused international research, development, demonstration and commercial utilization activities related to hydrogen and fuel cell technologies. The IPHE provides forums for advancing policies, and uniform codes and standards that can accelerate the cost-effective transition to a hydrogen economy; and it educates and informs stakeholders and the general public on the benefits of, and challenges to, establishing a hydrogen economy.

Since early the 90s of the 20th century IAHE and the Donetsk National Technical University (DonNTU) in accordance with their international agreement have assisted to international cooperation of different parts of the World Hydrogen Movement (see Appendix 2). At last IAHE and DonNTU international conference [75,79,80] there was adopted 'Memorandum on a Novel IAHE Conception of Hydrogen Civilization of the Future: Historical Aspects and New Challenges of the Present Day', which is bringing to the world intellectual community a novel IAHE doctrine, which is of course already published [2].

But, by the author's opinion the readers must have an opportunity to get acquainted with the most important part of the Memorandum just in this review.

12. New Challenges of the Present Day [2]

1. Future transition to Hydrogen Economy and then to Hydrogen Civilization will be an historical epoch-making transformation. Such a transformation being of a global scale one cannot be serene in principle. The

whole history of engineering proves this. On this way we'll come across global achievements, and stoppages, and maybe even stepping back.

So, the most important task of the humankind elite is to observe carefully and prevent negative technical and social tendencies of different nature but of 'Hindenburg syndrome' similar manner acting.

2. Generalized tasks of the foreseeable future realization demand:

A systemic and synergetic analysis of the possible stages of transition from the fossil fuel system to the hydrogen economy and then to the full hydrogen civilization with an estimation of probabilities of the Earth's biosphere and ecosystem coming into bifurcation states and an analysis of possible ways of further development.

A development and estimation of some possible multi-variant mechanisms of the influence and control of the processes of transition to hydrogen civilization regarding the development of the noosphere and a possibility of the occurrence of new mechanisms of its self-organization.

Analytical and practical activities to stimulate the process of transition to hydrogen civilization, such as:

- Consolidation of the hydrogen energy and ecological movements and winning over scientific communities of other endeavours to solve complex tasks through systematical studies.
- Achieving mass 'hydrogen-ecological' consciousness; attracting attention of the public at large through the mass media and educational programs at schools, colleges, universities, etc.
- Initiating extensive discussions and taking in international and regional organizations to enact laws and economic regulations of the processes of transition to the hydrogen economy and then to the hydrogen civilization.
- Initiating practical activities through the legal and economic controls for the development of hydrogen economy in countries, groups of countries, and the world.
- Achieving an extensive international cooperation in order to secure the participation's and contributions of the whole humankind to transition to hydrogen civilization.

3. A safety and efficiency of hydrogen industry, hydrogen technologies and hydrogen energy systems are based on the activities of the world hydrogen movement including three large international communities: hydrogen energy, hydrogen-materials and hydrogen-industrialists ones.

At this historical moment one of the crucial questions of the world hydrogen movement is a necessity of a wide information exchange and cooperation between leading representatives of these three communities. Just such cooperation

will make possible to anticipate some specific bifurcation points on the road to hydrogen civilization. For example, this way of looking at the problem has already come up with understanding of possible in near future world hydrogen economy commercialization crisis induced by deficit of platinum metals (tens and hundreds of tons of platinum per year).

4. Transition to hydrogen economy and then to hydrogen civilization will undoubtedly be accompanied by permanent global and/or local geopolitical and geoeconomical contradictions. In particular, changes in the national interests of many countries will take place – ‘old’ and ‘new’ energy resource owners, changes of geoeconomical interests of transnational energy companies. A polarity reversal might arise in the sphere of geopolitical and geoeconomical attractions and the like.

Generalized task of political elite and of all the humankind is to work steadily under legislative (not by force) governing of possible negative geopolitical and geoeconomical tendencies of the movement on the road to hydrogen civilization.

5. The time is ripe to establish an international system transmitting the totality of hydrogen knowledge and experience to generation after generation. Establishment and operation such an inter-generation’s system is a necessary condition of the safe and sustainable humankind movement along the environment friendly vector ‘Hydrogen Energy → Hydrogen Economy → Hydrogen Civilization’.

12.1. Elaboration, Discussion, Adoption

The Memorandum had been elaborated by IAHE pioneer team constituted from Professor V.A. Goltsov, Professor T.N. Veziroğlu and Dr. Eng. L.F. Goltsova.

The Memorandum has been discussed and adopted in the city Donetsk (Ukraine) on May 25th, 2007 at the Final Plenary Session of the 5th International Conference ‘Hydrogen Economy and Hydrogen Treatment of Materials’ (21–25 May, 2007) and recommended for publication in international and national scientific journals and in the public press.

12.2. Call for Cooperation

We, the participants of the 5th International Conference ‘Hydrogen Economy and Hydrogen Treatment of Material’, HTM-2007 (Donetsk, Ukraine, May 21–25, 2007), active elder and younger members of the World Hydrogen movement call on all members of the world scientific, ecological, cultural communities, industrial and political elites, everybody who cares for the ecological well-being of the humankind, preservation of the Earth’s biosphere and ecosystem, to consolidate the efforts and contribute to the approaching of

the Era of Hydrogen Civilization, the only one known as clean, efficient, sustainable, abundant and hospitable to life on the Planet of Earth.

On behalf of the participants – representatives of 28 countries, this Memorandum has been signed by 24 members of the World Hydrogen Movement, representatives of the elder and younger generation [2].

13. Conclusions

On the threshold of the 21st century there were arose pertinent historical conditions for conceiving a new mode of thought about the sustainable human future, Hydrogen Civilization. It was realized in the form of a novel Hydrogen Civilization (HyCi) doctrine (concept, study).

On a planetary scale the HyCi doctrine is based on Vernadsky's studies about the biosphere and the noosphere and in its analysis the HyCi doctrine leans upon synergetics, a modern science about the development of complex self-organizing systems, one of which is the biosphere.

The HyCi doctrine states that humanity can preclude world ecological catastrophe and conserve the biosphere's ability to sustain life only by movement along the vector: 'Hydrogen Energy → Hydrogen Economy → Hydrogen Civilization'. Historically prolonged movement in this direction will lead to global transformations in all aspects of human existence, human mentality, and human society, the mode of political and international thought, environment and industry friendly development. Correspondingly, the HyCi doctrine consists of three interrelated basic component parts: industrial–ecological, humanitarian–cultural, and geopolitical–internationally legislative ones.

In accordance with philosophical synergetic concept of the universe hydrogen civilization idea by its content, by its historical maturity and by its attractiveness as a public ideal can (and will) perfectly serve as a 'super-attractor', the motion to which will fill the forthcoming history of the mankind with a new sense.

For the first time, there are formulated two future historical stages (two phases) in the asymptotic mankind motion to superattractor, hydrogen civilization. The differences between them are analyzed.

There is expressed an idea that under the influence of philosophy, the knots of theoretical basis of the transition to hydrogen civilization will be further comprehended in the most generalized view.

The HyCi doctrine in its humanitarian–cultural basis reflects the world situation that the mass comprehension of the mankind and the elitist comprehension of a considerable (and even larger) part of the educated society do not realize yet that the real quality of human life is permanently deteriorating,

and especially do not perceive a historically near danger of the world-wide ecological catastrophe.

The HyCi doctrine asserts that a historical time interval needed to reach the first stage of hydrogen civilization when the mankind can already avoid the world-wide ecological catastrophe and save biosphere suitable for living can and must be shortened. This might be attained *by adopting a new humanitarian–cultural paradigm on the quality of the life and by introducing the system of ecological taxes.*

The rate of forming the humanitarian–cultural groundwork of the HyCi transition will fully specify the rate of the mankind sustainable motion to the ecologically clean Era of Hydrogen Civilization.

The HyCi doctrine uncovers the legislative–economical mechanism of the transition to hydrogen civilization. The HyCi doctrine formulates the stages of transition to the era of hydrogen civilization that will be put into operation in the 21st century accenting an attention on the world scientific–cultural community future noosphere role, on the principal importance of purposive forming ‘hydrogen–ecological’ mass consciousness and on the role and responsibility of international and regional legislative and political organizations, national parliaments and governments.

Further HyCi doctrine moving to the heart of the matter will be (and already is) a product of joint collective efforts of the thinkers of the world hydrogen movement, and then would be needed the noosphere efforts of the thinkers of all the world scientific and cultural community.

In summary it is necessary to emphasize that the HyCi doctrine is an optimistic one serving as a guide for an optimistic vision of the sustainable future of human civilization, Hydrogen Civilization. According to the HyCi doctrine, during transition to the era of hydrogen civilization, a paramount life self-organization will take place with an inevitability of a geological process, as in such cases Academician Vladimir Ivanovich Vernadsky liked to say with respect to the biosphere and noosphere processes.

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I would like to say to Dr. Jon O'M. Bockris, the great 'Hydrogen Enthusiast' and 'Hydrogen Romantic': 'Thank you very much, Jon, for a long intellectual leadership of mine, for your last publications, which are full of pain of the humankind future and, at last, my special gratitude to you for sending me your beautiful book, which help me to understand the details of hydrogen idea development in the 20th century'.

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Appendix 1

Goltsov: Mankind is at the Crossroads of H₂ Civilisation and Self-Destruction

16th WHEC Daily Report, No. 3, Friday, June 16, 2006, Lyon, France

Over the last 5,000 years the human population has increased 144 fold and its energy consumption 2,650 times. Clearly, this trend is non-sustainable and will inevitably lead to self-destruction of mankind...just as primitive reducing bacteria have been destroyed by their own production of oxygen...or as seen in the 16th Century painting ‘Parable of the Blind’ by Peter Brueghel the Elder, where a group of blind people stands on the verge of a great abyss. ‘Just like the blind, mankind is running toward its destruction if it does not make the right decisions now,’ explains **Prof. Victor Goltsov** from the **Ukrainian Donetsk Technical University**. Goltsov was deeply inspired by the work of the prominent Russian scientist V.I. Vernadsky (1863-1945) who analysed the nature, defined the boundaries and explained the open, synergetic and evolutionary nature of the Biosphere (a term invented in 1875 by the Austrian geologist Edward Suess). Believing in the strength of human reason, Vernadsky supposed that the collective scientific thought will overcome the negative results of the technological development and will secure the rational transformation (and not annihilation) of the biosphere, for a maximum satisfaction of the material and spiritual demands of the mankind. This future evolutionary stage of the biosphere of the earth was designated by Vernadsky Noosphere, the sphere of reason (a term introduced in 1922 by a French philosopher and mathematician Edouard Le Roy).

According to Prof. Goltsov, the hydrogen community must now establish how much time mankind has before the biosphere and ecosystems will enter into

an irrevocable catastrophic phase of self-destruction. In any case the transition to Hydrogen Civilization will not be serene and mankind will have to solve and prevent antagonisms and instabilities occurring during this transition by geopolitical, international and worldwide legislative action.

Appendix 2

Jubilee Greetings from the IAHE President

(The 4th International Conference ‘HTM-2004’; IJHE, 2006, Vol. 31, Issue 2, p. 151)

The Fourth International Conference ‘Hydrogen Economy and Hydrogen Treatment of Materials’, 17–21 May 2004, is devoted to the 30th Anniversary of International Association for Hydrogen Energy (IAHE).

It was some three decades ago, during the First International Conference on Hydrogen Energy (The Hydrogen Economy Miami Energy Conference, 18–20 March 1974, Miami Beach, FL, U.S.A.) when a small group of ‘Hydrogen Romantics’ got together. It was agreed that the Hydrogen Energy System was an idea, whose time had arrived. It was the permanent solution of the global environmental problems and the depletion of fossil fuels. Subsequently, the International Association for Hydrogen Energy (IAHE) was established by the end of 1974, and started working in earnest. One of the first activities of IAHE was establishing (in 1975) the *International Journal of Hydrogen Energy (IJHE)*, an official journal of IAHE, then organizing the biennial World Hydrogen Energy Conferences.

During those years, Hydrogen Energy was being also widely discussed in the USSR at the national conferences. For example, at the Conference ‘Gases in Metals’ (Donetsk, September, 1975) Professor Anatoly N. Podgorny and co-authors reported on the main ideas of Hydrogen Energy, and they found a broad response among the USSR scientists. In 1976, the main state journal of the USSR published the article by Academician Valery A. Legasov ‘Universal possibilities of hydrogen’. It was an official acceptance of the necessity to develop large-scale activities in Hydrogen Energy in the USSR. As a result, the USSR joined the IAHE.

During all these years, the Donetsk National Technical University (DonNTU), the leading technical university of the Donbass region of Ukraine, has been amongst the world renown universities in the field of Hydrogen Economy and Hydrogen Materials Science, thanks to the activities of a special hydrogen laboratory headed by Professor V.A. Goltsov, a scientist awarded (in June 2000) with the IAHE Rudolf E. Erren Award ‘for Outstanding Contributions to Hydrogen Energy in General, and to Hydrogen Treatment of

Materials in Particular’, a member of the Board of Directors of IAHE, and a member of Editorial Board of the *International Journal of Hydrogen Energy*.

Since the mid-1970s, national and international conferences on Hydrogen Energy and Hydrogen–Materials problems have been held in Donetsk biennially or triennially. At the previous conference (14–18 May 2001, HTM-2001), the ‘Joint Scientific and Coordinating Council on the Prospects of Transition to the Hydrogen Economy’ (JSC-Council) was established.

New times and new tasks require new solutions and now the new Journal ‘Bulletin of Hydrogen Economy and Ecology’, being an official journal of the JSC-Council, and under the auspices of IAHE, will inform and consolidate the Russian-speaking hydrogen community of the CIS-countries as a part of the World Hydrogen Movement.

It is with no great surprise then, that Donbass, one of the greatest industrial megalopolises in the world, with severe environmental problems, advocates the Hydrogen Economy, the only one known as clean, efficient, sustainable, abundant and hospitable to life on the Planet Earth.

My colleagues, participants of the Fourth International Conference ‘Hydrogen Economy and Hydrogen Treatment of Materials’, present or future active members of the World Hydrogen Movement, I wish you great success in your hydrogen activities. You can be proud of your contributions to the development of the Hydrogen Economy; good luck in your endeavours.

T. Nejat Veziroğlu,
President, IAHE,
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Victor A. Goltsov

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Professor Victor A. Goltsov is a member of the Board of Directors of the International Association for Hydrogen Energy (IAHE), a member of the Honorary Editorial Board of the *International Journal of Hydrogen Energy (IJHE)*, Editorial and Scientific Committee of *International Journal of Nuclear Hydrogen Production and Application (IJNHPA)*, Chairman of the Physics Department and the Head of the Donetsk State Hydrogen Laboratory of the Donetsk National Technical University. Over of several decades he has been working out hydrogen–

materials problems and general questions of hydrogen energy.

During the first years of the 21st century he has been steadily elaborating Hydrogen Civilization Concept – far-distant historical vision of the sustainable humankind future. On June 12, 2002 at the Meeting of Board of Directors of IAHE held in Montreal (WHEC-14), pioneered by Board Director Dr. J. Bolcich discussion of the novel IAHE HyCi concept had taken place and the presentation of the IAHE HyCi concept to the World Hydrogen Movement at the 15th World Hydrogen Energy Conference in Yokohama was recommended. This decision was fulfilled in the 30th anniversary year of the IAHE during the 15th World Hydrogen Energy Conference (Yokohama, Japan, June 27–July 2, 2004). The concept was presented at the Plenary Session to an audience of 2000 delegates from 52 countries. Following this, at the first years of the 21st century the novel IAHE HyCi concept was widely presented to the scientific community at the international hydrogen conferences: Istanbul-2005, Moscow-2006, Lyon-2006, Berlin-2006, Istanbul-2007, Donetsk-2007, Montecatini Terme-2007, Moscow-2008, Xi'an-2008, Delhi-2009, Moscow-2009 and were published in *IJHE*, *IJNHPA* and in many other journals and conference proceedings.

By now Hydrogen Civilization Concept (Conception) has made great strides toward its maturity and might be symbolized by other proper terms, ‘study’ or ‘doctrine’.

Victor A. Goltsov is awarded with the IAHE Rudolf Erren Award (June, 2000) for “Outstanding Contributions to Hydrogen Energy, in General, and to Hydrogen Treatment of Materials, in Particular”.

Further HyCi doctrine moving to the heart of the matter will be (and already is) a product of joint collective efforts of the thinkers of the world hydrogen movement, and then would be needed the noosphere efforts of the thinkers of all the world scientific and cultural community.