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SEARCHING FOR SUSTAINABLE ENERGY: A NEW ANALYTICAL MODEL

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The high average consumption of electric power in a country means that the population reached a higher development level than those who has lower level of consumption. The warm and adequately-lit home is considered a basic need, together wiith access to energy-consuming appliances ranging from the fridge to the TV. Actually, everyone should have access to this energy to heat and illuminate their lives, enabling survival, study, health and leisure at acceptable cost. Behind the access there is the question of energy production. When this production doesn't change the climate, flora and fauna, then we say that this is sustainable energy.. Even in developed countries like UK, yet low incomes, energy-inefficient housing and appliances mean that about 10 per cent of UK households fail to attain this basic standard. When we studied other countries around the globe we observe that many people still live without energy. The purpose of the current paper is to present the approach about energy in view of sustainability. We develop an analytical model for sustainable energy using basically two theoretical concepts: the Laws of thermodynamics and the McDonough and Braungart fractals model, which involves equity, ecology and economy. After presenting the new model, we tested using the data collected from more than 250 papers in selected European journals between the years 2006 and 2008 (however for reasons of space, here we present only the analysis of nuclear and hydropower). We see the model works and concluded the most sustainable energy is still nuclear power, despite the common sense not to say that. It has volume production, the cost acceptable, on short-term is not limited to material and does not contribute to the greenhouse effect.

Palavras-chaves: Energy Policies, Sustainable Energy, Sustainability

1. Introduction - The concept of electricity

Even without knowing exactly what electricity is, the modern man and woman cannot live without consume it. It is understood that electricity is a public good, though the service is sometimes managed by private sector. As a public good, governments must protect the interests of citizens.

The study of energy goes back to ancient Greece. The fourth century BC, Aristotle said that energy was a "reality on the move." Many researchers have attempted to redefine the concept of energy. In 1824, Leonard S Nicolas Carnot proposes the first relationship between heat and work and Rudolf Clausius formulated the concept of entropy. These studies enable the establishment of the fundamental laws of thermodynamics:

1ST LAW	Energy already exists. It can only be processed, but never created
2ND LAW	Sets a limit for the transformation of heat, based on the concept of entropy
3RD LAW	The absolute zero is the temperature that cannot be reached

Table 1: Laws of thermodynamics - Source: Van Wylen (1998)

In this sense, the concept of power from classical mechanics, defined as the measure of the ability to perform work, but with restrictions, is determined by the second law. The fact is we all need energy to transfer the human efforts for engine, heat their homes, light their paths. However, examining the laws of thermodynamics, we realize that energy production is limited, and involve large financial sums and, especially in their use, change the habits of human beings and change the climate of the earth, causing great concern.

Through these laws and the triple parameters (equity, ecology and economy) used by McDonough and Braungart (2002), we have developed and present a new approach to sustainable energy. Through this concept, we compared several forms of energy production (but show only two) and conclude (contrary to popular knowledge says) that nuclear energy is the most sustainable energy.

2. The Sustainable Energy

The question of the use of clean and sustainable energy (CSE) is not only an appeal by environmentalists as the early 70, but a global issue, given the advance of global warming and ecological accidents occurred followed. Electricity can be produced from energy provided by wind, water, sun, tide, fission or fusion processes, waste, sugar cane bagasse and even from the combustion of various chemical products. The biggest problems are the shortage energy sources and the pursuit of clean generation, without causing environmental problems.

Countries must choose energy sources that have as low impacts on climate and environment as possible. However two main problems arise for renewable energy sources: a) they are not transformed at large scale and b) they are expensive. For this reason, a number of studies, show in the table1 below, have been developed.

ANGLO-SAXON / GERMAN	Neoliberalism and environmental policy - need for economic compensation mechanisms – certificates	TOKE, David; LAUBER, V.
ARGENTINA	Renewable energy policy needs mechanisms implementation	RECALDE M.; GUZOWSKI.
ASIA	Policy mix, coupled with strengthened cooperation at national, local and regional levels	ZHANG, Zhong Xiang
AUSTRIA/ SLOVAKIA	The confrontation between two nations with different sets of electricity policies about nuclear power plants	LOFSTEDT, Ragnar
AUSTRALIAN	Considering the nuclear option	SCHLAPFER, August.

	Nuclear processing industry and the re-emergence of nationalism	HAY, James L.
CANADA	Little use of wind power; increase with hydroelectric, combustible renewables and waste	LIMING Huang. et. al.
CHINA	Study on probability density function and distribution function of electricity prices	ZHOU H et. al.
	Use SHP	ZHOU Sheng et. al.
	examines the potential effectiveness of the renewable energy policy	CHERNI Judith et. al.
BELGIUM	Bio-energy - Distortions in agricultural	KADITI Eleni
USA	Main policy dimensions of the policy debate over hydrogen: applications of hydrogen, plug-in drive trains, and gasoline.	COLLANTES Gustavo
INDIA	Wind energy in India has an extremely bright future.	GOLAIT Neeraj, et. al.
	Wind power - The various policy parameters were combined.	RAO K. USHA ET.AL
GREECE	Cyprus needs to guarantee sufficient energy supplies and create necessary infrastructures. Introduce natural gas	PILAVACHI .A., et al.
SWEDEN	Emergency management in the Swedish electricity market: The need to challenge the responsibility gap. Need for societal support.	PALM Jenny
	Examining energy and agricultural sector policies.	ENGSTRÖM Rebecka, et. at.
TAIWAN	To promote the use of biofuels - Increase the subsidy and Studies about impact the agricultural matrix.	TSAI Wen-Tien
NETHERLANDS	Restructuring energy systems for sustainability? Energy transition policy in the Netherlands.	KERN Florian, SMITH Adrian
SPAIN	Evaluating environmental regulation in Spain using process control	LÓPEZ-GAMERO MD. et. al.
LITHUANIA	The largest total installed capacity of wind farms, which could cause no significant increase in power transmission	MARKEVIČIUS Antanas, et. al.
	Use of nuclear as an option to reduce gas emissions	STREIMIKIENE, Dalia
ITALY	Environmental effects in Sicily and the role of renewable energy.	BECCALI Marco, et. al.
INDONESIA/ JAPAN	A proposal for cooperative activities between Japan and Indonesia in the field of Nuclear research.	SUBKI Iyos
SOUTH AFRICA	Renewable energy policy needs mechanisms implementation	SEBITOSI A.B.; PILLAY, P
	Industry needs restructuring	GAUNT C.T.
IRELAND	Using indicators to profile energy consumption and energy policy.	OGALLACHÓIR B.P. et. al.

Source: placed in the framework

What we realized is many countries, as Germany, Sweden and France, seeking policies that encourage the use of CSE, but they are still much the use of hydroelectric and nuclear plants. Then, for us evaluate this use; we created a definition of CSE.

There are several definitions of CSE, all visions involving individuals that try to justify this or that ideology. However, there is no way to escape or forget the concepts involving principles of preservation of the environment, economy and equity.

Under production management concepts, this model still cannot cover all the sectors of production. There are others subjects like supply chain and the production scale model, with productivity, efficiency and effectiveness that must be addressed. (Primo and Amundson, 2002; Choi and Eboch, 1998, Lambert and Cooper, 2000). So our hope is to include the analysis component related to economy and therefore, the model of fractals (McDonough and Braungart,2002), seen from the laws of thermodynamics viewpoint, offers a perfect approach to do so.

Then a question is compulsory: Can you generate electricity without affecting the environment? No.

PREMISE 1 - Following the 1st law of thermodynamics, there is no generation of energy, but an exchange of forms of energy. Human beings are able to develop a technology to transform existing stored, latent energy in nature, into electric power, heat (industrial furnaces) motion (cars) or brightness (lighting) among others.

PREMISE 2 - Because of the 2nd law of thermodynamics, there is a limit for processing, and then there is no possibility of a 100% recovery of the latent energy of nature. As a

consequence, there are losses, which generate different types of leftovers related to Ecology (A), Economy (E) and Equity (Q) losses.

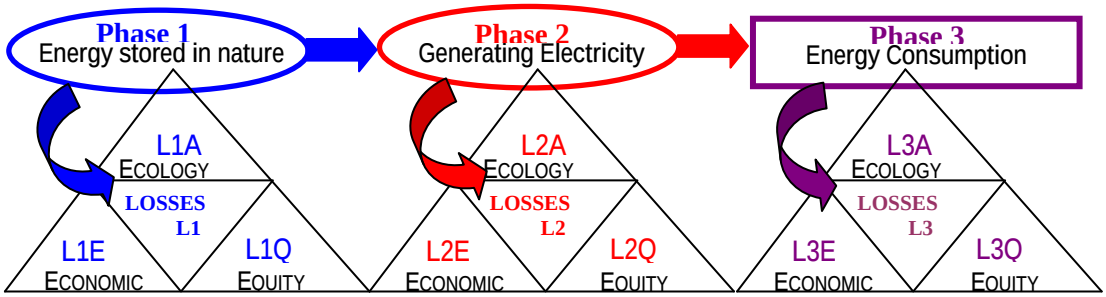

Figure 1: Steps of transformation: the energy contained in nature to consumption

Considering the two premises (law of thermodynamics and the triple parameters of equity, ecology and economy), we can simplify the above construction, creating our assumption to CSE, as follows:

ENERGY = CONSUMPTION + LOSSES.	*So when the losses tend to zero, we found the CSE.*

There are other models of sustainability like “The cleaner production” but, in essence, all generation of sustainable energy is seeking to minimize the losses, whether (i) the quantity of waste, (ii) the impact on the environment; (iii) financial cost or (iv) the impact of these leftovers on the society.

In our case, the concept of "loss" does not necessarily follow the common definition of “trash”, as organic waste from hospitals or waste from a residential building. The scope of this concept is broader; it includes tangible and intangible sub products.

The losses are those shown in Figure 1. L1 are the losses generated in the first phase of collecting the raw material as it exists in nature, for energy generation. For example, the dam water for hydropower causes environmental losses with intangible financial value, because many ecosystems are flooded. This biodiversity loss is an environmental L1A.

The L2 losses are those related to the power generation, in produced by joule effect (heat in transmission), hearing effect, decrease of efficiency and other, associated with the process of generation and transmission. This is an economic loss L2E.

The losses L3 are intrinsically linked to the consumption of energy, as a simple consequence of individuals’ actions. For example, they can choose to have a "disposable- pet-bottle" of soda instead of that one bottled in a recyclable glass pot. The environmental costs of the pet bottle option would be classified as a loss L3A.

On the other hand, if the second option is chose, there would be no environmental loss, but an economic loss L3E, caused by the cost of collecting and washing the glass bottle.

There are tangible and intangible losses in all power generation processes. We can apply this concept to decide on whether a power generation process is clean or not through these losses. In this case we see that, in fact, the term "clean energy" could never be used alone, but an idea of comparative processes: an generation energy processes can be cleaner than other, depending on the losses.

For example, when it is decided to implement a co-generation system (burning sugar cane) in a Sugar-Alcohol Plant, an environmental loss L1A is generated: the volume of CO_2 placed in nature (Clement, 2003). In contrast, the residues (the burning straw or even pre-harvest products) would cease to exist.

In this case, both ethanol production processes, with and without the co-generation system, emit CO_2 to environment. Then, comparing the cases, we can conclude that the process with co-generation produces cleaner energy. Of course, the problem of emission of CO_2 continues, but with the co-generation, there is an overwhelming case in favor of human beings: the production of electricity.

In that sense, the best possibility for producing CSE would be **the one that minimizes the full impact of losses, considering equity, ecology and economy.**

Moreover, in some cases there is the possibility of obtaining "positive losses" and in this case we are talking, in fact, in real earnings. The positive "loss" represents an advantage of one source over another. Coming back to CSE meaning, a parallel with cleaner production definition can be useful for the purpose of this paper.

The United National Industrial Development Organization UNIDO - defines the cleaner production as a preventive strategy that must be integrated and used in all phases of the production process, according to Diaz Pires (2005) because it: (a) Increases productivity through efficient use of materials, energy and water; (b) Promote the improvement of environmental performance by reducing waste and emissions and (c) Reduces the environmental impact of productive processes throughout product life cycle assessments, by means of an efficient and environmentally friendly design.

In that sense, the cleaner production and CSE concepts aim to preserve the environment and the community wellbeing, while simultaneously seeking sustainable growth of organizations through improvements in efficiency, profitability and competitiveness. In our case, CSE is reached by minimizing the impacts of losses, based on the laws of thermodynamics, where nothing is created and everything is transformed.

3. Analysis of the Hidropower

There are many countries where hydropower is the primary form of generation, such as Brazil, Canada, Colombia, Venezuela, New Zealand, Switzerland and Norway (Rangel, 2008), and all have appropriate policies for its operation (Silva, 2006).

This forms of energy production is show cost more cheaper and the technology more efficient (see Garcia-Gonzalez et.al.;2007) - yield hydraulic electric power around 90% - than when hydropower is combined by wind power it achieves high performance (Angarita & Usaola, 2007).

Indeed, Mammana (1994, p.184) said at that time that the concept of clean energy in hydroelectricity is vague and only is true in relation to the final consumer, because normally there are losses L1A, such as those inherent to the process of capture and accumulation of water, the formation of large reservoirs, flooding of land, submerged natural resources, productive land and forests, among other things.

When a reservoir is formed, large cultivable areas are flooded; there are irreversible biodiversity that modify the hydrological cycle. There is more rain, more moisture and fauna and flora are altered by new conditions. In general, the change of the climate, indirectly changes the relationship of man with nature.

When a city is flooded to build a reservoir, human beings are affected. In this case, there are losses L1Q due to the fact that the citizenship is changed when people are forced to change, leaving everything literally under water. In other cases ethnic differences were ignored and in

some others, there were several public health problems such as endemic diseases that compromised the quality of water in reservoirs, affecting human activities as fishing and agriculture.

Thus, according to Bermann (2007): “Although the Hydroelectricity does not contribute to the increase of CO_2 emissions in Brazil, it implies a socio-environmental liability extremely significant considering that the hydroelectric dams that have been built so far resulted in more than 29 thousand km^2 of flooded land and the expulsion of about 200 thousand families who lived on the banks of the river”

In this case, Santos (2007) complements this issue: "This clean, renewable and cheap energy, justified on behalf of the public interest, modernization, progress, and development, has not benefited local community."

About Small Hydro Power SHP, there is not a this problem, there is not possibility of flooding of large areas, but returns the question of the little amount of energy produced (Kaldellis, 2007; Purohit, 2008; Bruno & Fried, 2008).

Then, there are still L1E losses that are related to the big initial investment and the long term return on capital investment. In medium size plants, this return is around 20 years (Silva, 2005). On the other hand, it should be emphasized that the cost of production of hydroelectricity in the world is very low (Rangel, 2008). In consequence, there is a disadvantage connected to the initial investment but at the same time there is the promise of future competitiveness related to profit.

There are also some L2A losses. The transmission lines in the fields and cities with a mesh of wires, towers, cables and transformers affect the landscape: There are electrical losses by joule effect (heat generation) and corona effect (noise), so the energy is not so clean unconditionally.

Silva (2005) confirms that the concepts of renewability and inexhaustibility should also be reassessed. All the primary sources for power generation are being depleted; they are sedimentation of rivers and basins, and exhaustion of fossil or nuclear fuels.

With regard to renewability, while the hydrological cycle (solar heating) adapts to new conditions, it also promotes processes like corrosion of dams and turbines (by increasing acidity of water, for example). Over time, you need major investments to its maintenance (L2E).

In this context, there is no doubt that environmental programs such as the Itaipu Ecomuseum, Park birds, fish ladder, the CHESF (Company Hidreletrica do São Francisco) as tourism in the Canyon of San Francisco, FURNAS and others in Brazil (for example), are actions to be followed, but we must not forget they are palliative, and a poor compensation for the damage that hydropower plants cause to the environment.

An interesting case to mention is connected to the rivers Madeira (RO), Jirau and San Antonio dams: the approval of this structure building was approved by IBAMA (Brazilian Institute of Environment and Renewable Resources) with 33 restrictions.

For example, the creation of programs for monitoring of sedimentation, periodic measurements of the concentration of mercury and monitoring of the period for breeding fish were mandatory, minimizing in this way the environmental impact of construction, inherent to any project of that size (Rodrigues, 2008). In this case the economic losses L1E are increased but the ecological and social losses L2E, L3E, L2Q and L3Q are reduced.

4. Analyses of the Nuclearpower

Since its early years, nuclear industry promised clean energy, cheap and inexhaustible, which is a topic great controversy. Indeed, there is scarce information about nuclear fusion or fission processes and their impacts, which are totally different.

According to Verbruggen (2008), nuclear power and renewable energy are “the main options to bring down the carbon intensity of commercial energy supply”.

This direction, Knobel (2007) says that when "merging light atomic nuclear (such as isotopes of hydrogen, deuterium and tritium), there is a huge release of energy, a process that is known as atomic fusion." This process is similar to what happens inside the Sun and other stars, and could be a limitless source of energy for future generations.

The process of nuclear fission was discovered by Hahn, Meitner and Strassman in 1938. It occurs when the uranium is bombarded by neutrons, the nucleus breaks into two pieces, turning into lighter atoms, such as barium and krypton. "The energy on the nuclear forces that unites the pieces is released in the form of kinetic energy (energy of motion) of the fragments." (Buys, 2007).

Its global visibility comes with Hiroshima and Nagasaki that until today dismay humanity. So, you ask: what clean energy, cheap and inexhaustible is that? What are the residues from production of nuclear energy?

In respect of losses relating to nuclear fusion, there is still no sufficiently reliable assessment. There are studies in the field of physics, but application in the generation of energy is not yet in commercial stage. It is known, however, that the cost of nuclear fusion is very high, (Knobel, 2007) and it will only be economically viable around 2040-2050, because of the expectation of shortages.

Knobel (2007) say that: “Nuclear fusion presents a vast list of qualities connected to environmental safety. There is not a chain reaction. The radioactivity from nuclear fusion is similar to the radioactivity of a thermo-electric plant. Fusion does not produce climate change, CO_2 emissions or pollute the atmosphere. However, it still depends on considerable investment”.

There are various types of losses connected to nuclear fission that you can see:

L1E: The plants are capital-intensive, and require large initial investments

L2E: It is a technologically complex industry requiring specialized technology and highly skilled labor. It requires a centralized decision, pyramidal hierarchy organization and control over local society.

L1E: Production costs are at least 4 times more expensive than those for Hydroelectricity

L3A: Displays strong environmental impacts, not only in cases of accidents such as that occurred in the plant from Three Miles Island in 1976 in the United States, and with that of Chernobyl, ten years after the former Soviet Union, but in its normal operation, it produces an atomic waste that currently, still has no effective treatment. According to Pereira (2007) there is an accumulation of radioactive material of long half-life, yet to be accommodated in their final repositories, and the accumulation of plutonium in batteries of discharge of the fuel element.

L3Q: Access to any of these stockpiles of plutonium, either by unscrupulous individuals or followers of radical movements in society, can establish the illegal trade or even spread terror on a global scale, as a result of the destructive potential that it concentrates.

Supporters of nuclear power argue in its defense two true facts:

a) It has no problems with shortages of fuel and;

b) There is not emission of CO_2 in the atmosphere, so does not contribute to the increase of global warming.

Maybe that is the reason because countries like Belgium, Sweden and Germany, still depend on nuclear in a very large degree to meet their demands for energy. They have not given any signal that they would change this situation. In Germany, the Green Party predicted disconnect the nuclear reactors in 2000 but ended up postponing disabling total for 2021 (Pereira, 2007).

Weisser et.at. (2008) state at present there is no binding agreement (at a global level) to address the risk of anthropogenic climate change after 2012, and in this case, the nuclear power plants have an important effect.

Indeed, even expensive and polluting, nuclear power has the voltage and frequency stability and it has enough raw materials for the next 500 years. So, no industrialized countries either abandon these trusts. Therefore, given the uncertainties of other energy sources, nuclear energy is the alternative supply of electricity on a large scale. It is a question of power. (Portilho, 2005).

Accordingly Högselius(2009) show five broad explanatory factors are identified like question of power: military ambitions and non-proliferation, technological culture, political culture and society, geological conditions, and energy policy

Clean nuclear energy? Far from it, the intensity of radiation, which originates from strontium *90* is 28 years; cesium *137* is 30 years; uranium *238* is 4.5 millions of years. In 2003, Sweden had a referendum on the permanent use of nuclear energy, and people decided not to use it. However, in 2009 the Swedish government informed the public of the need for nuclear generation.

In UK was a researcher where the consistent message is that while higher proportions of the British public are prepared to accept nuclear power if they believe it contributes to climate change mitigation, this is a highly conditional view, with very few actively preferring this over renewable sources given the choice

We need remember: nothing is created, everything is transformed, but one thing is but one thing is certain: we humans, we should not change our genetics.

5. Conclusions

The physicists Hawking (2004) warns that even if the rates of energy consumption worldwide stop growing, in the year 2600 the earth will shine as a small sun in the infinite universe and then he says that this is impossible. Indeed, the world biggest concern is not to light up the Earth, but to get real possibility of monitoring the growth of electricity consumption, either by: (a) increasing production, (b) increasing the use of efficiency and (c) reducing consumption.

The countries have two sustainability energy problems: “the need to avoid climate change and the need to replace traditional crude oil as the basis of our transport system” (Forsberg, 2009).

This paper presenting a new approach to CSE, in addition is also a review of recent relevant literature. We observe no CSE in unconditional form and we say the need for more production and availability of energy increase environmental problems on our planet.

Portilho (2005) goes beyond pure analysis of the electricity matrix and focus on the idea that patterns of production should be modified, on one side, through the replacement of raw materials, and in the other side, with the decrease of waste obsolescence and discarding planning for their products. "But the patterns of consumption must be radically reduced…especially referring to the consumption of high-income societies throughout the world, without exception”.

The greenhouse effect on earth cannot be neglected. The decision process on the energy matrix of each country must take into account the sustainability of the planet. According to WRI(2001), fossil fuels account for about 85% of primary energy consumption worldwide, 35% oil, coal 28% and 22% natural gas. If the current pace of global consumption is maintained, estimates indicate that the currently proven reserves of oil may meet the global needs for the next 45 years, the natural gas for the next 52 years.

This study aimed to use the laws of thermodynamics to develop a constructive analysis of the two electricity system sources. The scheme shows clearly that these challenges may require tight coupling of different energy sources to produce electricity to all demand, and meet other energy needs. In addition:

(1) From the 1st law, no electricity is created, but it is the result of a transformation;

(2) From the 2nd law there are limits to this transformation, so there are always losses. Sometimes they are material waste, sometimes with consequences to humans, that is, this transformation causes impact on the environment and generates consequences for modern man and woman;

(3) Also from the 1st and 2nd laws, when withdrawn the potential energy of fuel, on only the trash, then conclude that all primary sources of energy are exhaustible;

(4) From the 1st and 2nd laws: There is no CSE so unconditional;

(5) From the 3rd law, connected to absolute zero concept, it is impossible to stop nuclear activity waste.

With the loss of the processes of power generation and consumption, we can only suggest to seek its minimization. So now what is the cleanest way to produce electricity? Despite different opinions, in the context of this research, we take the risk to answer that it is the Nuclear Energy.

On the other hand, we know that this statement is very questionable and can generate endless questions. We cannot answer that question in a simple way, because:

• The hydroelectricity offers the cheapest KWh of the world and does not emit CO_2;

• The thermoelectricity offers a more flexible possibility and, if we use biofuels, it has a great advantage because is CO_2 neutral, but presents problem of scale;

• The nuclear case does not emit CO_2 in nature, have good reserves, but there is the radioactive waste disposal problem. It can be buried in underground buildings, deposited in

granite areas of stable tectonics or use rockets and throws the garbage in outer space (the Hollywood solution).

Forsberg (2009) ensure Nuclear–hydrogen peak power systems may enable renewable electricity sources to meet much of the world's electric demand by providing electricity when the wind does not blow and the sun does not shine.

In your study, Weisser et. al.(2008) concludes that, overall, post-2012 climate change policy should aim at providing policy flexibility without compromising technology flexibility, and Nuclear energy attend this question.

On another hand, Carvalho et.al.(2009) says that in Brazil the investment in nuclear is unnecessary because there is great potential by hydro power in this country. Lee et.al.(2008) show in Korea, is impossible to decide how the scenario will be the next 20 years (nuclear or coal) due to insufficient domestic energy resources.

Alternatives, predictions, solutions, global forums are looking to answer this question. Each country has its own particularities, but the solution has to address the welfare of the planet. Technically, all solutions are possible, but have losses in three areas (equity, ecology and economy). Matsui et.al.(2008) and Aillancourt et.al. (2008) sad the analysis suggests the need of long-term planning and R&D efforts under the wisdom. Abram et.al.(2008) work with scenarios and seeks to develop a new generation of nuclear energy systems for commercial deployment by 2020–2030.

Both researchers reach the conclusion that nuclear energy technologies satisfy a large portion of electricity production in many regions and other renewable technologies might play a more important role but need further cost reductions or new regulations to penetrate the market in substantial proportions.

In fact, Pidgeon et.al.(2008) conclude your discussion indicate that "it would be unwise, in the UK as elsewhere, to simplistically assume that there exists any single or stable public 'opinion' on such complex matters".

Finally we say: currently you cannot stick only to economic and financial costs, it is necessary to take care of nature, the sustainability of the planet and especially of human beings.

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