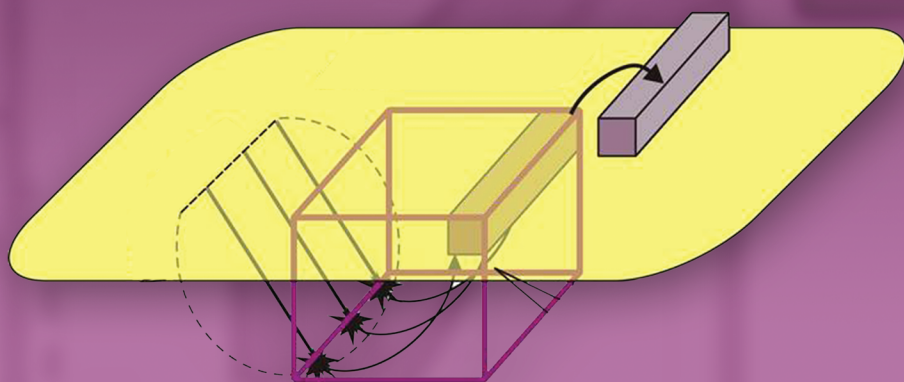


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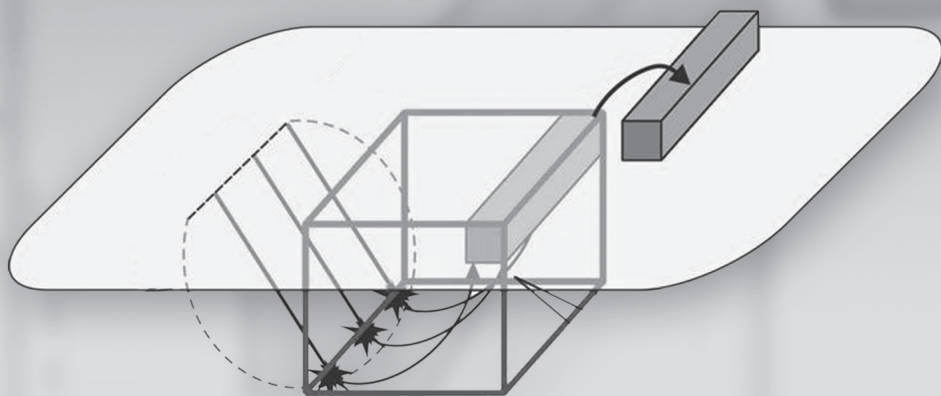
# Nanobiotechnology in Energy, Environment, and Electronics

Methods and Applications





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*To the memory of Dr. Alexey A. Peshkov, my very dear friend, outstanding Russian scientist, and correspondent member of the Russian Academy of Sciences, for his long scientific activity towards new megatechnologies—namely the development of mineral deposits by the technogenic initiation of directed geological processes—that a premature departure has suddenly terminated, leaving, however, to us his important scientific contribution witnessed also in this volume.*



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# Introduction: Present Challenges and Future Solutions via Nanotechnology for Electronics, Environment and Energy

**Claudio Nicolini**

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Oil fuels the modern world, but oil is a finite resource. It brought great changes to economies and lifestyles in less than 200 years and nothing else to date equals the enormous impact which the use of oil has had on so many people in so many ways around the world. The critical question is, however, “When is or was the maximum daily amount of world oil production at its peak?” After that, oil is going to become an irreversibly declining resource facing an increasing demand, which will not be met. The world passed its peak of rate of oil discoveries in the 1960s, and it seems that the peak of world oil production will then be reached by 2020, and possibly within the next decade (Campbell, 1997; Campbell and Laherrere, 1998; Ivanhoe, 1995).

What are then going to be realistic alternative energy sources for humanity among the existing renewable or non-renewable one (Table 1)?

Fusion involves the fusion of either of two hydrogen isotopes, deuterium or tritium. Deuterium exists in great quantities in ordinary water, and from that perspective fusion is theoretically an almost infinitely renewable energy resource. This is the holy grail of ultimate energy. Fusion is the energy that powers the Sun, and that is the problem. The temperature of the Sun ranges from about

10,000 degrees Celsius on its surface to an estimated 15–18 million degree Celsius in the interior where fusion takes place. Containing such a temperature on Earth in a sustainable way and harnessing the heat to somehow produce power has so far escaped our search. However, even if commercial fusion will be accomplished, the end product again is likely to be electricity, and not a replacement for fuel sources such as oil and gas.

**Table 1**      Alternative energy sources

Non-renewable	Renewable
Oil sands, heavy oil	Wood/other biomass
Coal	Hydropower
Shale oil	Solar energy
Gas hydrates	Wind energy
Nuclear fission	Wave energy
Geothermal	Tidal power
	Fusion
	Ocean thermal energy conversion

Questions are sometimes raised as to using **hydrogen and fuel cells** for fuel sources. Neither is a primary energy source. Hydrogen must be obtained by using some other energy source. Usually it is obtained by the electrolysis of water, or by breaking down natural gas (methane  $\text{CH}_4$ ). Hydrogen is highly explosive, and to be contained and carried in significantly usable amounts, it has to be compressed to hundreds of pounds per square inch. Hydrogen is not easy to handle, and it is not a replacement for pouring 10 gallons of gasoline into an automobile tank. Fuel cells have to be fuelled; most use hydrogen or some derivative of oil. Fuel cells are not a source of energy in themselves.

Oil appears to be a unique energy source that up to now has no complete replacement in all its varied end uses. British scientist Sir Crispin Tickell concludes, “...we have done remarkably little to reduce our dependence on a fuel [oil] which is a limited resource, and for which there is *no comprehensive substitute in prospect*.” Coming to realize that oil is finite, any and all suggestions of means to replace oil are obviously welcomed, but so far only cheerful myths are enthusiastically embraced. These include: that there are two trillion

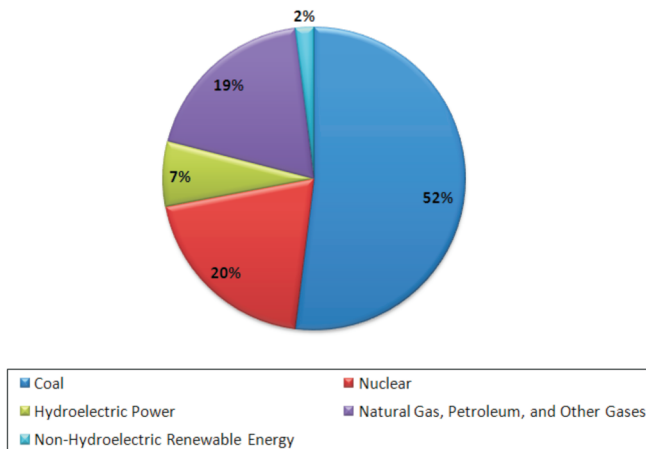


barrels of economically recoverable oil in the Colorado Plateau oil shales; that dams and their reservoirs are a source of indefinitely renewable energy and that they are environmentally benign; that solar, wind, geothermal and hydro-electric power can supply the electrical needs, from the Arctic to the tropics, of the Earth's **over six billion people** (likely to further grow in the near future); that coal, oil from oil sands, and biofuels can replace the 72 million barrels of oil the world now uses daily; and that somehow electricity produced from various alternative energy sources can readily provide the great mobility which oil now gives to the more than 600 million vehicles worldwide. Regrettably, **none** of these cheerful myths appear up to now to be valid, including the mega-myth which represents the most popular public placebo that "The scientists will think of something" as I did witnessed myself few months ago at Orlando during a short visit to Disneyworld. The energy spectrum from burning wood to fusion that fuels the Sun (Table 1) is now well known. If there is some major exotic energy source beyond what is here listed, we have no evidence of it and the reality appears to be that the world is rapidly running out of a resource (oil) that in many ways appears irreplaceable. We have been living on a great fossil fuel inheritance accumulated during more than 500 million years that humanity has incredibly exhausted in the last period in less than 200 years. We will soon exhaust this capital, and we will have to go to work to try to live on current energy income. It will not be a simple easy transition as pointed out in a remarkably perceptive book written by Darwin in 1952, where were described historic changes in the human condition, calling them "revolutions." Darwin wrote that there is one more revolution clearly in sight: "The fifth revolution will come when we have spent the stores of coal and oil that have been accumulating in the earth during hundreds of millions of years...it is obvious that there will be a very great difference in ways of life..."

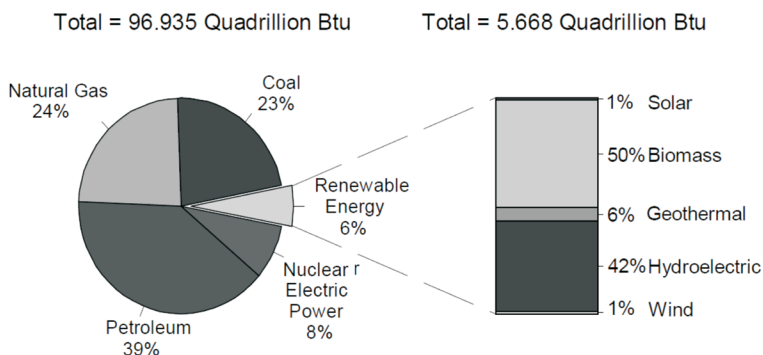
The present energy situation is exemplified in Figs. 1 and 2 from what has been occurring in the United States in the recent time.

Similarly, the **natural disasters** have been increasing in number and frequency in the last few years permitted by the wrong myth that humanity could do without the Kyoto agreement attempting to control the devastating **carbon dioxide** effects. As in the preservation of oil reserve, the humanity and its governments have

failed also in the protection of natural environment. In summary, the result could become very shortly a great change in economies, social structures and lifestyles, and the opportunities for science and technology to make a difference are becoming constantly narrower. And this despite the striking development in **electronics at the nanoscale**, through the construction of new effective nanosensors and nanoactuators.



**Figure 1** US electricity net generation by source for 2000 (EIA Annual Energy Review) *Source: International Energy Agency.*



**Figure 2** Renewable energy in proportion to total US energy supply. *Source: Energy Information Administration (EIA).*

It is, therefore, essential to find concrete solutions to the growing problems in all sectors of the economy, such as energy,

environment and electronics, and worldwide the situation could be overcome only by a wide internationalisation involving the leading countries in economic, military and financial terms, namely the **Russian Federation**, the **United States of America and Europe**. Furthermore, only at the nanoscale, we can hope to embark on such undertaking with some degree of success. It is the right moment for the United States and Russia to unite with Europe their forces and to concentrate all the possible resources to solve the dramatic problems affecting the entire world as those illustrated above, involving resources and facilities from leading multinational companies, as well manpower coming from citizens of the above three large countries which should change their priorities and return to science and technology as for the past full of long stories of successes. I know this will work for the entire world's benefit and for my personal direct experience having passed my entire life in these three large communities extremely productive in R&D. Attempt to do this at the national scale with large recruitment from underdeveloped countries is bound to failure because the magnitude of the crisis induced by the derivatives has far lasting devastating effects (continuously coming to light) and because the magnitude of the technological problems long time underestimated is unmatched at any single isolated nation scale. The scheme based on multinational companies, that in the past was able to work for Italy in Bioelectronics with Polo Nazionale Bioelettronica and CIREF (both centred around Italian-based multinational companies as ABB, Montedison, FIAT, ST Microelectronics, Olivetti, Farmitalia, Elsag-Bailey), may still be valid but this time only if the above named three large countries, frequently in the past on opposite sites, find means to cooperate in order to achieve the required critical mass at the world scale. An institution (Fondazione EL.B.A.) indeed in the past was born and did grow with participation of organizations at the crossing of Europe, Russia and the United States and constitute the proof of principle that something similar (Nanoworld Institute) could become again the triggering factor between Europe, Russia and the United States. In the past, the Biochip Project initiated by President Gorbachev through Academician Velikov (USSR) and President Craxi through myself (Italy) did work and I do not see why should not work now, despite the larger scale and the more ambitious objectives. I hope that the time has passed for science to be at the service of arms race

among between the United States and Russia, and the reduction of nuclear arsenals and waste being pursued in START (STrategic Arms Reduction Treaty) should further aim not only to avoid their falling in wrong hands and to increase global security (as suggested by President Obama in the 2013 State of the Union), but also to transfer all these military resources in **joint civilian project**. Recently in an open debate with President Putin organized by Russian television I raised via the Internet a question (subsequently acknowledged) about the opportunity of final disarmament within the “Measures to Further Reductions and Limitation of Strategic Offensive Arms” treaty between Russia and the United States such that the enormous resources spent could be used for the development of joint projects in nanoscience and nanotechnology for energy, health, electronics and environment.

Cancer at the molecular scale is strongly interlinked to differentiation, ageing and proliferation, but also to ecology, and solving it we will solve major correlated problems in life sciences. Energy is strongly interlinked with power generation, automation and environment, while similarly is happening (at the nanoscale) for really intelligent hardware, being strongly interlinked to communication, defence and environment. Indeed the risk of upcoming ecological disasters, including global warming, can be reduced or avoided with the development of new energy sources nanotechnology-based from sun, wind and hydrogen. The far-reaching effects will be beneficial for the entire humanity and for the survival and growth of earth. Last but not least is the objective to bring back the prestige of science among young people to correct the economical disasters caused by bankers and financial institutions.

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