On Energy Research

by Dr. Boyko Nitzov
Senior Expert, Energy Charter Secretariat

"The Stone Age did not end because we ran out of stones."

Of Stones and Energy

I've frequently heard this adage, often ascribed to Sheikh Zamani, the former minister of oil of Saudi Arabia, at conferences and other events. I googled the maxim – exactly as it appears here - and got about 40 hits. Many of them were in web postings dealing with the topics of the day: the dependence of the economy and on oil, its price, the structure of its market, and the eventual transition to the use of other sources of energy in an "end of the world" drama or in a less exciting way. I acknowledge the importance of these aspects – a good maxim has many facets.

But what has taken my fancy for some time now is a somewhat less direct aspect of the saying: was getting away from stone tools and on to metal ones an entirely spontaneous process? How did it work exactly? Was the art of reducing copper, zinc and iron into malleable form from non-descript ore "stones" a skill onto which Fred Flintstone stumbled upon by chance or revelation? Or maybe some stone-age giant of mind did a bit of research, observing and experimenting, prompted by what was already known about naturally occurring metals, such as gold nuggets and meteorite iron? Did he fund the research out of his own private means, or his family tolerated his tinkering while having to do all the hunting and gathering and feed him supper?

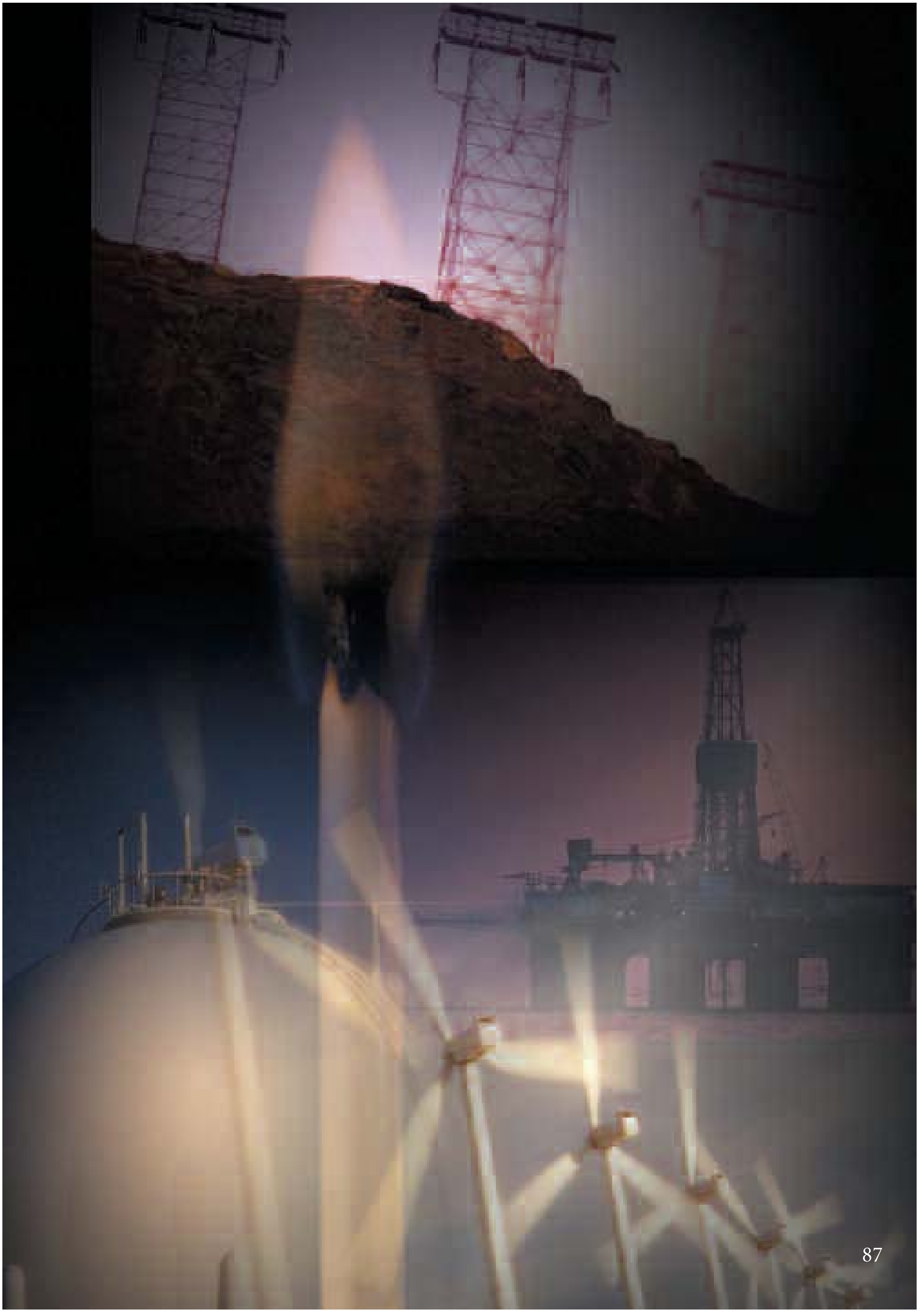
And what might the implications have been for the kin of that discoverer? On one hand, did his clan embrace right away the superior novel tools, or was it a lengthy process? On the other hand, what fate befell those other people that were not in possession of the breakthrough technology?

Well, it is the last of those questions that I think I have some idea how to answer. Take a look at what happened in various parts of the globe to many of the folks who still lived in the Stone Age when they had to face European colonizers with advanced tools – and weapons.

But let all this rest in peace. What I am concerned about is the possibility that today's approach to research in energy may be tilted to the short-term perspective, in disregard of the possible long-term consequences. If true, this would mean that at risk are literally the growth, welfare and security of nations that do not find the proper ways and means to support energy research. Here's why I think this may be so.

In the Long Run, We Will All be Dead

Energy permeates modern society in an unprecedented way. Electricity is a good example of that. Take it out of the picture as if it



never was, and you will lose your heating, cooling, cooking, lighting, and most likely water supply. Oh, and your car will not run without electricity. Not to mention the fridge, TV, radio, computer, washer and dryer. No phone calls, either. Sewage will fail a bit later. How fun was the latest New York blackout?

Access to secure supplies of modern commercially supplied forms of energy is a sine qua non for our comfortable, advanced, sophisticated and reasonably pleasurable lifestyles. Nations that do not have such access live in misery – and languish there at that. And if you think that applies to electricity only, think twice.

Well, hardly anyone who is involved in energy is not aware of this. The public at large knows about the value of energy, too. Why then do we manage to combine a good measure of concern about running out of, say, cheap oil, with an equally good measure of nonchalance about research and development in energy?

I think the answer has a lot to do with a failure to differentiate between the products and the consequences of research in energy. It is this failure that leads to the preponderance of the short-term outlook. I am not the first one to pay attention to this fact. For example, in 1997, S.E. Cozzens noted that the available research performance indicators measure the short-term outputs of research, not the long-term outcomes. But it is the outcomes that define our lives.

Among the indicators that typically measure the merits of research are publication counts, citations per publications, doctorates produced, undergraduates involved, user involvement and satisfaction ratings. Want to know how outputs relate to outcomes when this set of criteria is applied? "The problem with the set, of course, is that it leaves out virtually all of what researchers themselves find important about their work. One could have a government full of programs that performed beautifully according to these indicators, and still be at the trailing edge of every scientific frontier." – Cozzens

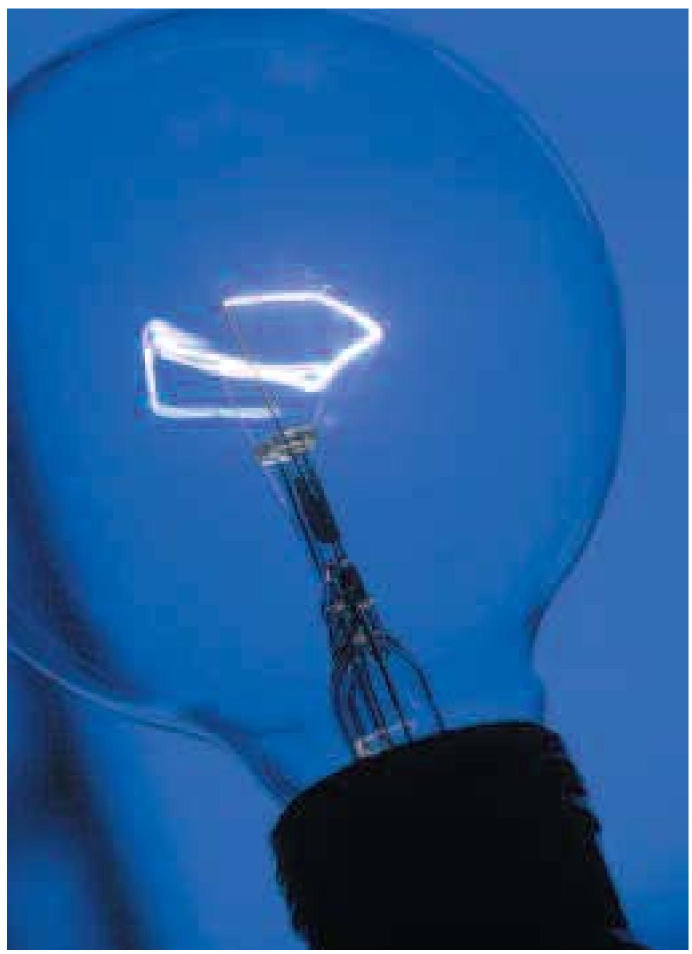
Now, were that to be true, what would it mean to be dependent on energy for virtually every aspect of our lifestyles, but be on the trailing edge of research and science in energy? I will not go into a discussion of the implications. I would just like to share that I am concerned what the implications might be. For example, one of them could be that a nation that fails to adequately support research in energy would fail to support its long-term security and prosperity.

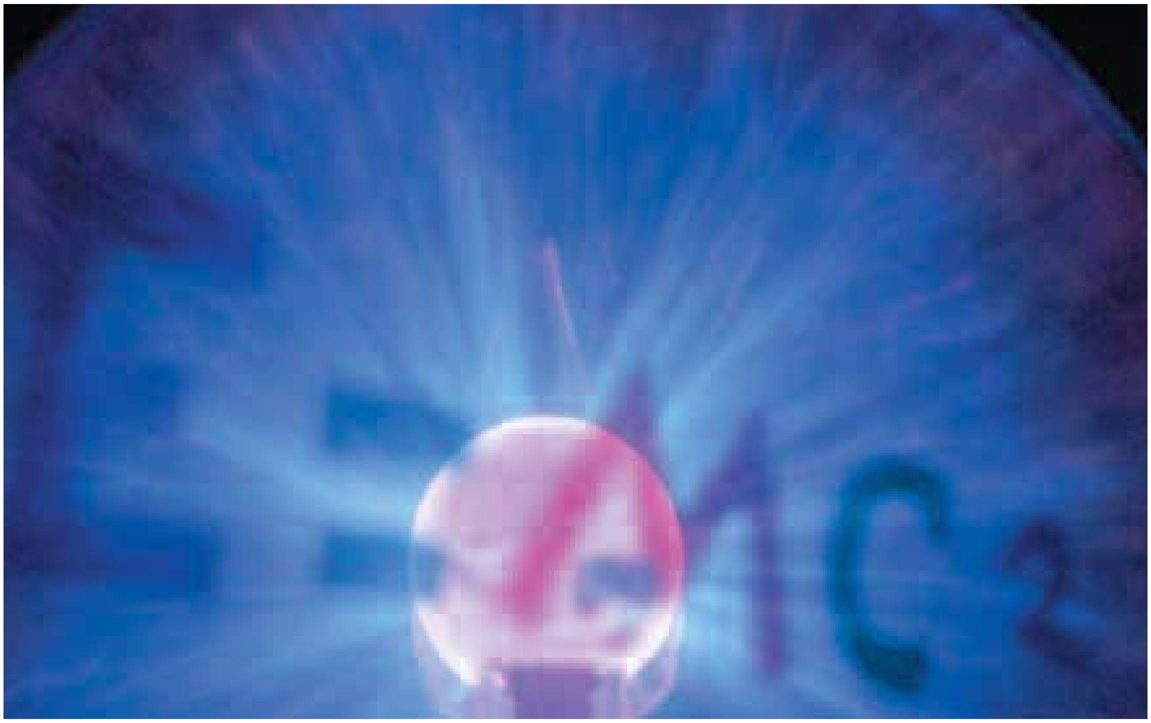
Privately and Publicly Funded Research in Energy: In Balance?

Equating marginal costs with marginal benefits is pretty straightforward and works fairly well when decisions are made on funding research programs designed to achieve a certain output. More often than not, such research programs are technology- or product-oriented. Some say Edison did not have trouble privately funding 3,000+ experiments, carried out with the help of a team of 10+ paid employees at a cost of $10,000 – when cheap labor cost ¢7/hour – in order to improve the electric bulb and get a patent. He even reportedly failed 10,000 times in his experiments to develop an electric storage battery, but was not deterred a bit: "Why, I have not failed. I've just found 10,000 ways that won't work." – Edison. Nor was Edison stopped by subsequent costs in bringing the bulb to market to the tune of $300,000 (including $100,000 in patent litigation). But maybe all of this is because Edison also turned out to be an avid businessman?

Nikola Tesla, famously opposed to Edison's use of direct current, also did not have trouble funding his research privately, eventually developing a complete line of products for the generation, transmission and use of alternating current – much the same that we use today. Some argue that it is because of positive externalities that research in energy should be supported from public funds. There is fairness in this argument. Edison was simultaneously technically savvy and entrepreneurial; hence, he became quite rich. Tesla's business skills were far inferior to his talent in science and technology, and he ended his life in destitution and debt, alone in a hotel room. Both got ample private funding for their research, and in both cases the public benefit from their work clearly exceeds both the private cost and the private benefit. So… fund energy research because of its positive externalities and the private-public benefit argument?

To a degree, yes. I just do not think the argument is best used when output-oriented research programs are considered. I tend to think that where output can be defined in terms of product, technology, and economizing inputs to a production process or other clear-cut (short and long-term) benefits, there will be no shortage of private R&D funding. Because of the positive externalities, public





The major failure may be in funding research where value is harder to define. For example again, in 1905 Einstein published not one, but five papers, four of which (on Brownian motion, the photoelectric effect, and the two on special relativity) are believed to deserve Nobel Prizes.

funding in these cases would be just supplemental. But markets do work in the case, after all.

The major failure may be in funding research where value is harder to define. For example again, in 1905 Einstein published not one, but five papers, four of which (on Brownian motion, the photoelectric effect, and the two on special relativity) are believed to deserve Nobel Prizes. He was living out of means provided from his daytime job as an officer at the Swiss Patent Office. The Nobel Prize that he did get was for the paper on photoelectric effect – in 1921. Being just a humble layman in these fields it is hard for me to judge, but it appears that many significant long-term outcomes of Einstein's work are not in the area of the photoelectric effect. It took 40 years, and the publicly funded Manhattan project, to reveal one of these major outcomes, and about 15-20 more years to begin commercially generating electricity at nuclear power plants. Would private investors have wished to support Einstein's pursuits in 1904-5 if they had known that a major outcome of his research would be both atomic explosions and atomic energy? The real beneficiaries in the case seem to be the WWII allies – and all of us, indeed.

The strategic benefits of publicly funded energy research fail, as a rule, to be recognized in the short run. For product-oriented research there are ways to compensate. A supplemental mechanism drawing on public funds is easier to put in place, monitor and judge its performance with the help of cost-benefit analysis and other well-known methods and tools. Basic research is a priori a different case.

The Changing Notion of "Basic" Energy Research

There are some additional considerations that one may contemplate when dealing with energy research. First, energy research is a fair case of what is often described as "interdisciplinary." Physics, chemistry, material science and mathematics are but a few of the branches of knowledge that one has to deal with if the field of research is "energy." Fossil fuel energy will also bring into the picture earth sciences (geology, geophysics, etc.). Would Einstein's research in 1904-5 have even been recognized as "energy research?" He wrote for Annalen der Physik.

Second, today the pace of progress in energy is on a different scale from what it used to be during past millennia. The path from "basic" to "applied" research to "design" to "production" to "marketing" is much shorter. Take into consideration that energy is a productivity tool. It is like having all around us a myriad of gnomes that do work instead of us (remember the blackout?). So what happens to those who do not support the steps on the pathway from "basic" research in energy to the application of the outcomes en masse? I would say the productivity growth of such nations would likely be on the low side, eventually eroding the base of their growth and welfare. Yes, this process can also rely on private markets – but please mind the output/outcome argument.

Third, the interdisciplinary character of energy research and its fast pace tends to result in the proliferation of various energy technologies that could (and do) serve the same purpose. But having more choices would really not be a problem, right? Maybe, unless you have to invest in energy R&D.

The proliferation of competing options means, inter alia, that investors have to bet on one or more, knowing that eventually most bets will be down. This time around, let's take an example that is less lofty than Einstein's pursuits, closer to the day than Fred Flintstone, and makes our hearts mellow: cars. For a century, there has been little doubt that the best solution for whizzing them around is a reciprocating internal combustion engine fired with derivates of petroleum. Right now, on top of that option one has to consider (a) entirely different prime movers (e.g. fuel cell) and (b) entirely different fuel base (e.g. sugar, grain or cellulose-based ethanol, hydrogen made from natural gas or by electrolysis from water, natural gas, synthetic liquids made from either natural gas or coal), to name a few. A 2001, General Motors Corp., et al study looking at the best system on a well-to-wheel energy efficiency and greenhouse emission basis lists some 50+ options ("pathways") in which energy could reasonably get from its primary source ("the well") to the wheels. Care to invest in one or more of them?

However, even the proliferation of options in major energy-related technologies and products would not be a problem for investors who make choices in a competitive market environment. The risks pertinent to such an environment are handled well by decision makers. The problem is that the various options ("pathways") have a different structure of inputs and are looking at different timeframe for market penetration, factors that did not exist when 99%+ of the cars had under the hood the good old four, six or eight cylinder pusher. For that reason, a regulatory decision (say, higher federal fuel efficiency standard), which would be by and large neutral regarding manufacturers of cars relying on the "standard" petroleum burning reciprocating engine, would have a very different impact on the firms looking at other pathways.

Simply put, in an environment where the outcome is subject to significant regulatory risk, novel energy technology may not find sufficient private funding support for up-front R&D. It would probably then be fair that the party that causes the risk carry the up-front risk cost. For example, ethanol is now competitively produced and used in cars in Brazil. However, it took hundreds of millions of dollars in subsidies and many years to get to that point. The benefit? A prominent expert, A. Lovins, in Winning the Oil Endgame, says public benefit for that country (e.g. resulting from reduced cost of imports of oil) exceeds the initial public outlays 50+ fold.

I guess there is a clear need for continued public funding for energy R&D in cases like these, as long as spending is accompanied by persistence, consistency and transparency of policies. Public support for energy R&D is in this sense a sharp but two-edged instrument for risk mitigation. It is efficient when objectives, ways and means are clear-cut and sustained, and wasteful and counterproductive when focus changes with the wind of the day and the tilt of the lobbying.

Outsourcing Energy Research: Outsourcing Growth and Prosperity?

Not necessarily. Output-oriented R&D may be good to outsource, since such outsourcing would reduce private cost incurred in R&D, make the relevant products more affordable and help increase the rate of their market penetration. For energy-related products, this would mean achieving greater energy efficiency sooner. Still, an additional qualification seems necessary to me.

Output-oriented research falls into two broad categories: incremental improvement of a known artifact (product, technology, etc.) and cross-field innovation (e.g. combining known artifacts in a new way). I tend to think that the first one should be entirely left to private entrepreneurs, and on top of that, if these private entrepreneurs decide to outsource it to another nation on cost-saving grounds, so be it. The second one is a bit trickier and may need public support for the purposes of risk minimization, as indicated.

Outsourcing basic energy research, however, would impact a special aspect inherent to fundamental research in general, not necessarily basic energy research only. "Science proceeds through a slow process of accretion of results. Major breakthroughs do not necessarily occur on a regular basis, and an essential element of scientific research is the replication of earlier findings in order to confirm or generalize them. Moreover, new research findings are significant not just because they yield a new technical application, but simply because they help to add to the precious stock of scientific knowledge available for future human use." – Cozzens

Much has been said and written about the benefits of public spending on enabling infrastructure in other sectors, for example the benefits of interstate road infrastructure. Few doubt the positive long-term outcome of this policy, adopted some 70 years ago and sustained to this day. States and communities insist on having more and better roads, subsidized with public funds. I would say basic energy research is an enabling activity, just like the modern infrastructure. In these days of globalization it may as well be a good thing that at least we can't outsource the roads.

Of Cost and Value

One final observation on cost-benefit analysis: out of the need of insurers, health care and safety, environmental impact assessment and globalization, the notion of "value of life" as a statistical term was born. It is usually defined as the marginal cost of death prevention, i.e. the cost of reducing the average number of deaths by one. "Willingness to carry risk" and "willingness to pay" came out of these needs, too. Since folks from poorer countries will take risky jobs for a lower pay than folks from richer countries, the resulting "value of life" in poorer countries under this approach would be lower than in richer countries. This was the assumption of the economists who created the global cost-benefit analysis of climate change for the Intergovernmental Panel of Climate Change (IPCC), stirring quite a backlash.

Once again, what is at stake if energy R&D is not adequately supported? What risks are we prepared to carry and what price are we prepared to pay in case such R&D fails?

Lights Out

If you cared to read up to this point, you may have noticed that there are a couple of dozen question marks preceding these last two. I have more questions than answers. It is the answers that I think I do have to some questions though that prompted me to share my concerns. We cannot make a transition to a better energy future without adequate R&D in energy.

The opinions expressed in this article are Dr. Nitzov's, and not necessarily those of the Energy Charter Secretariat or any other entity.

Boyko Nitzov is currently on an assignment as Senior Expert (Investment) at the Energy Charter Secretariat. He is formerly an Associate Director of the Institute for Energy Economics & Policy at the University of Oklahoma. Dr. Nitzov is an energy economist with a diverse background in academics, business and the petroleum industry. His experience includes the management of large-scale international technical aid projects, the concept development of major energy sector undertakings, project and country risk assessment, and other economic, market and policy aspects of the world energy industry. His research focus is comparative studies in methods of pre-investment studies in the energy sector. Dr. Nitzov has applied his range of technical and scientific capabilities to important energy relationships and large scale upstream natural gas industry projects, pipelines and LNG projects in many regions of the world