Prospects and Problems for World Energy:

Remarks at the World Renewable Energy Congress

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Regretfully, I have come to conclude that the world as a whole has missed the boat on evolving a good working plan on global energy for 2020. This date is too close for us to hope that revolutionary changes will occur in our lifestyle and in energy technologies.

Perhaps we have the ability to plan properly for 2050. What will the situation look then? I wish to share some elementary thoughts.

The world's energy needs will be growing much more steeply from now than at any time since the beginning of the industrial revolution. The numbers I quote below have been rounded off.

The population of the industrialized world was roughly a billion in 2003, and the energy consumed by it in that year was about 9 TW-h. The population in developing countries was about 4.7 billion and their total energy use about 4.5 TW-h—roughly 5 times the population and half the energy use. Thus, if all developing countries use as much per capita energy as industrialized countries, the energy demands will go up by a factor of 10.

The world's population is still increasing. The population is expected to stabilize around 9 billion. If all 9 billion people were to use the same per capita energy as in industrialized countries today, we will need roughly twice as much yet again—or a factor of 20 more than we now do.

These are upper bounds and asymptotic, and perhaps not very useful. One has to modify them for the time horizon we are considering; and 2050 is a useful target because it takes nearly that long to harness new technologies profitably and to change habits globally.

During this period, increasing energy efficiency will make a dent in our needs. Developing countries will take a long time to catch up to the energy needs; and, regretfully, some of them never will. The industrialized countries will cut down on their wasteful energy habits. And so forth.

Yet, there is no doubt that we will need much more energy than now. If the poor parts of the world merely catch up to the world average (which is weighted heavily by the users at the low end), a factor of 2 or 3 more energy will be needed. This estimate is primitive yet realistic. Moreover, additional energy needs are likely to emerge—for example, in meeting future water needs via, say, desalination.

Keeping 2050 in mind, we can ask: where is this energy going to come from?

It cannot be all from oil. Oil wells will slowly dry up. The recent increase of oil prices has already damaged the economies of developing countries (and those of the industrialized countries as well, but the fundamentals of those economies are in better shape). Yet, it is only a harbinger of tougher times to come—both economically and politically. If the present CO_2 emission per year of about 25,000 million tons is doubled, we will be living in a world that will look very different and far less hospitable.

It will not come from nuclear fusion either. A commercial fusion plant is at least 50 years away, even if everything with the ITER project at Cadarche, France, works according to plan and additional up-scaling occurs as expected. ITER will take 20 or so years to work fully and at least one intermediate generation of fusion plants will be needed before commercial success becomes a reality. Fusion will thus play no role until 2050—though it may play an important one beyond.

Nuclear fission today supplies about 16 percent of the world's energy (but the distribution is geographically lopsided). To bring it to 80 percent or so—roughly as in France now—one will have to increase the number of reactors five-fold. This is what will be needed if we go the nuclear fission route to fill up the void of diminishing fossil fuels. Let's forget for the moment about the lack of technological know-how in many countries, the limited sources of uranium, and difficult reprocessing and storage issues associated with spent fuel. Just consider, instead, what it will be like to dot the world's landscape with five times as many reactors as now. This step will likely increase the risk of accidents, magnify security issues many fold, and exacerbate the concern for proliferation of nuclear weapons.

Will it come from hydrogen? According to experts, there are basic problems with hydrogen as an energy source at the thermodynamic and conceptual levels, as well as at practical levels. One should not forget the principal point that hydrogen, though an excellent carrier of energy, is not a source. Thus hydrogen may play some role, but not the dominant one that fossil fuels now do.

What about renewable energy? That there is an abundance of it, no one doubts. The carrot is also that, if we can harness it successfully, one does not need to be constrained by energy conservation! Considerable progress has been made on renewable energies, especially in Western Europe. Issues related to these technologies form the central theme of this Congress.

But renewable energies face several obstacles. They are often characterized as "peanuts", and the principal issue is that it is too much of a "retail" commodity. And the gain of the hard-earned progress made by a few countries will have essentially come to naught by 2020 on the world-scene because of the additional gain in population. It follows that the impact of any progress made will not be felt on the world at large unless that progress carries with it the major parts of the world population. This is the stark reality. The action needed is not just technology, or even money, but it is the mindset and politics. It is even possible that a very large-scale harnessing of solar energy can have an impact on local environment, if not on the global level. These issues have to be addressed without prejudice.

In summary, looking towards the horizon until 2050, oil will become less available, the use of coal cannot increase dramatically without doing interminable damage to the environment, fusion will play no role, hydrogen will remain fairly marginal, and nuclear fission can be expected to increase slightly. Renewables will not be able entirely to fill the vacuum created by depleting fossil fuels.

So, what pragmatic approach should we adopt?

First, the world economy is so conditioned on oil that, despite the great uncertainty about the source, it cannot rapidly switch to anything else. As long as the last oil well remains operational, oil will be the preferred source of energy. Thus, it will have to remain in the mix of our energy portfolio for the foreseeable future.

Second, nuclear fission will play a moderately stronger role than now. Lately, its acceptability seems to have increased because of the absence of greenhouse effects.

But renewables should play an increasing role, not least because other forms of energy will become more expensive or less available. Some energy consumption is indeed retail, and there is no reason why, especially in much of Asia, Australia, Africa, and the Mediterranean, some household energy cannot come from the Sun, or why wind energy cannot be harnessed more effectively in countries like Morocco. Equally importantly, one needs to work, with the same level of seriousness as with fusion or fission, on large-scale solar power plants. This task is both high-tech and non-trivial.

To repeat, it would seem that a reasonable goal for 2050 is primarily a three-way mix of renewable energy, fossil fuels and nuclear fission, perhaps in decreasing proportions when averaged over the world, with others thrown in as minor partners. By 2050, we will surely know more about such things as fusion, hydrogen and the large-scale harvesting of renewable energy (in which category

solar energy will figure dominantly), and we will have to readapt ourselves to a new equilibrium point for 2100. Continual evaluation and adaptation are the keys to a more secure energy future.

If today's developing countries follow the same technological path as industrialized countries followed during their ascension, it is certain that there will not be adequate resources to meet the energy needs of the world. Developing countries, some of which have the “luxury” of taking a fresh look at the energy crunch, should look for new and alternative approaches. This requires clear awareness of the issues involved, deep understanding of potential technologies and, as a precondition, much research and knowledge of science. I cannot argue in favor of science any stronger than by stating that it is a matter of survival: increasing number of problems will depend on science for their solutions. This is my major, though general, point.

I will end with a few words about my own institution, the Abdus Salam International Centre for Theoretical Physics (ICTP). ICTP was created to support the building of scientific capacity in all parts of the world, especially developing countries. Its focus has been basic sciences. Nevertheless, since it was created under the umbrella of IAEA, it has been concerned with energy from the very beginning. The Centre's first long-term program in 1964, in fact, focused on fusion energy. Since then, ICTP has had a sustained interest in renewable energies. In total, the Centre has organized some 30 courses on this topic. Some 2000 scientists worldwide have taken part and are now involved directly in renewable energy projects in their own countries. Furthermore, through our Training and Research in Italian Laboratories, or the so-called TRIL program, we have supported some 400 post-doctoral scientists to come to Italy and work on projects of renewable energy. This represents a substantial investment on ICTP’s part, and strongly indicates that we recognize the seriousness of the scientific issues involved, and are committed to address them.

With respect to renewable energies, ICTP has had strong collaborations in the past with Professor Ali Sayigh, and I hope that they will intensify in the years to come. Collaborative and concerted efforts should be welcome by all: if we do not face our energy challenges together, the prospects of meeting them at all will dim forever.