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Mitigation Costs and Benefits from a Global Perspective

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New technologies are needed for providing the essential services to the needy as well as improving the quality of life in the more affluent parts of the world. Technological change improves the performance while lowering the costs as well as the adverse environmental impacts of human activities at all scales, from local to the global. Consequently, the diffusion of new technologies at affordable costs is the key determinant of economic development and is essential for raising standards of living and easing humanity's burden on the environment.

Climate change is a central aspect of adverse impacts of human activities on the environment. Thus, the challenge is to improve human well being while simultaneously mitigating anthropogenic climate change. The role of technology in achieving this double challenge is unique. Technology is one of the main driving forces of increasing greenhouse gas (GHG) emissions. It is also an important part of the possible solution in mitigating global warming through reductions of GHG emissions, in helping adapt to its impacts and offseting some of the adverse impacts trough geoengineering options. Technology was very important in catalyzing the historical drive of doing more with less – from increasing efficiency of factor inputs to reducing some of the adverse impacts of human activities – and it at the same time important driving force of ever-higher (per capita) consumption levels. In a way, this is the paradox of technology of being both a part of the problem and a part of the solution. The main energy-related technology measures for reducing GHG emissions are efficiency improvements, decarbonization of fossil energy, carbon capture and storage (over hundreds if not thousands of years), and a shift toward less carbon-intensive and zero-carbon

energy sources.

Generally, cost reductions and improvements will be required to assure timely replacement of fossil intensive systems by new and advanced technologies with lower or zero emissions. At the same time, technology improvements through learning and increasing returns to scale are uncertain. Investments in new and advanced technology will only achieve improvements and cost reductions in some cases. However, the corollary is also true, without such uncertain investments there surely will be no improvements. Thus, experimentation and accumulation of experience are indispensable to achieve technological change and the replacement of old by new systems. This calls for a global process and timely local and international action. This also means that early emissions reductions, even if only humble, are necessary for buy-downs along learning curves for some of the more successful technologies. Thus, the nature of technological change requires innovations to be adopted as early as possible in order to lead to lower costs and wider diffusion in the following decades. The longer we wait to introduce these advanced technologies, the higher the required emissions reduction will be. At the same time, we may miss the opportunity window for achieving substantial buy-downs. This requires both RD&D as well as investments to achieve accelerated diffusion and adoption of advanced energy technologies.

Current energy RD&D trends are unfortunately in the opposite direction. Public expenditures in OECD countries have declined to some $8 billion from about $12 billion two decades ago, while private ones have declined to $4.5 billion compared to almost $8 billion a decade ago. This means that today we are investing barely about $2 per person in the world per year in energy-related RD&D activities. Many studies indicate that this needs to increase by at least a factor of two to three in order to enable the transtion toward new and advanced technologies in the energy systems. Investment needs in energy are at least a factor 100 larger compared to RD&D needs.

Future energy investment needs are huge with estimated $20 trillion from now to 2030. This translates into about one trillion dollars per year or at least twice the currnent level of investments with most of the requirements being in developing parts of the world. More sustainable development paths require 10 percent higher investments. All told, RD&D efforts need to be trippled and energy investments at least doubled in order to assure the timely replacement of energy technologies and infrastructures.

The additional costs of stabilization are relatively small in comparison to these ovearll investment needs. They are in the range of 10 percent or about $2 trillion by 2030. The great benefit of these additional investments into a future characterized by a carbon-leaner energy systems and a more sustainable development path is that in the long-run (to 2050 and beyond) the investments would be substantially lower. The reason is that

the cumulative nature of technological change translatesw the early investment into a carbon-leaner future into lower costs of the energy systems in the long run along with the cobenefit of stabilization. This all points to the need for radical change in energy policies in order to assure sufficent investment in our common future and thereby promote accelerated technological change in the energy system and end use.