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A Postmortem Technology Assessment of the Spinning Wheel: The Last Thousand Years

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I have been asked to say a few words before this conference parts about our thinking, if you like, on technology assessment, in relation to the work of IIASA's Energy Systems Program. With a time horizon of about fifty or perhaps a hundred years, technology assessment is an essential part of it. However, since we do not produce methodologies of technology assessment, what I am going to convey to you most probably is the grumbling of the consumer.

First let me redefine technology assessment, because what I have seen in the papers presented here somehow escaped the strict definition of technology assessment, which is the *analysis of secondary and tertiary effects upon the socioeconomic system of the introduction of a new technology*. Consequently, if one studies for instance, the effect upon the drivability of a car of putting the engine in front or in the back, this is not technology assessment but system analysis. In this sense, most of the work of the Energy Group is systems analysis even if the subject is, for instance, the effect of using large amounts of coal on transportation, on the conservation of resources, on pollution, including pollution at the level of the entire atmosphere, etc. I would say that technology assessment at a certain moment requires *qualitative discontinuity*. For example, when we look at the introduction of nuclear energy into the socioeconomic system, trying to understand the change in the organization of the socioeconomic system that results from the introduction of nuclear energy, we are engaged in technology assessment.

Yet in doing that we are at a loss because out of the thousands, or perhaps hundreds, of scenarios—as we call our configurations—there is at best one that will be realized, and we lack any real criteria to detect it.

Having tried to find the knots of the problem, I would say that, in a nutshell, the difficulty in doing technology assessment stems from the *imponderable and historical opportunity*. Let me show this by using an example from a speech of Lynn White, a medieval historian.[1] It spans a thousand years, a period that lends the necessary historical depth many technology assessments lack, I am afraid, and that brings out the problem of historical opportunity and the consequences of the imponderable on the evolution of a system.

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[1] Lynn White, Jr., "Technology Assessment from the Stance of a Medieval Historian", *Technological Forecasting and Social Change*, *6* (1974), Elsevier-North Holland, New York, pp. 359–369.

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For some ten thousand years, or five, or something of that order, man has dressed in clothes. Clothes are made from fiber, and the fiber was then painstakingly twisted into thread by hand, the thread woven into cloth, and the cloth shaped into a dress. If you "linearize" your clothes, you would be astonished how much thread there is in a suit—it may be a kilometer or two—and in the original way of making that—by twisting the thread from a bundle of fibers with the help of a small tool—an innumerable number of hours went into the making of that thread. This spinning was so important and time-consuming that a moral value had to be attached to it, and in fact the Roman matron of virtue stayed at home and spun the wool, as was written on the epitaphs: *Domui mansit, lanam fecit.* The quintessential breakthrough was the invention of the spinning wheel, which happened in China, around perhaps the year one thousand. The year of 1050 saw the first drawing of this machine, which speeded up by a factor of 10 or perhaps 100, the rate at which the bundle of fibers was spun. This led to an obvious breakthrough in the production of clothes around the year 1200, when the machine slowly diffused to Europe, where the already existing loom was a quite efficient machine with respect to the known spinning methods. Thus the bottleneck of spinning was removed.

You may ask people in technology assessment what is going to happen when a bottleneck is removed and production increased. Many more clothes will be made, and many more rags will be thrown away, he will answer, and you will have a problem of disposal and pollution. An American technology assessor, asked about the consequences, would probably reply that you have to carry out research on how to burn rags, or perhaps, how to recycle rags which is somehow nasty because the fibers are so tightly twisted. Burning them you will have ashes and carbon dioxide, but everything can be cleaned up easily. What actually happened was quite different. The very large amount of rags was used by a new industry, again an import from China—the paper industry. Paper was in very short supply around 1200 because of the paucity of rags. So there was a bottleneck. On the other hand, books were in short supply because, in order to make a good thick bible, for instance, one to two hundred sheep or calves had to be killed to make parchment out of their hides.

Thus the bottleneck was not writing a book but the cost of making the material on which to write. And there was no real incentive for improving the efficiency of the system of writing. But when the avalanche of rags came in, a relatively cheap paper was available; then the cost of writing a book became essentially the cost of the amanuenses who had to spend days and weeks and months to copy the book down. So the bottleneck became these amanuenses, and to remove it one had to run the amanuenses fast. The best way of doing that is to invent printing, and so automatically from this *historical opportunity*, printing developed—not out of a vacuum but from a call from the system which I call historical opportunity. So there was printing, and paper, and books. Lots of books, and cheap ones.

Cheap books are a quintessential element in the diffusion of knowledge within a society, and the spread of knowledge brought about a quite important social revolution. Societies tend to stratify and to stabilize themselves by stratification of knowledge. The increasing diffusion of knowledge down to the lower strata of society has been considered necessary—historical opportunity again—for the constitution and evolution of democracy. So finally, modern democracy is a direct, if not necessary, consequence of the invention of the spinning wheel in China about one thousand years ago.

How can you now put that chain of elements and opportunities into a model that helps you to forecast the future? The task seems desperate, and we feel that. I have checked which other branches of science face a similar situation. The nearest appears to be biology where essentially the same problems have occurred since Darwin because the focus of evolutionary theory has been mutation. Mutation can be considered a technological innovation, whose causes are ***imponderable***, that is being tested against the ***historical opportunity*** of the existing structure of biological systems and their external boundary conditions, which determine the probability of their success. From what I have seen of the technical literature in biology, the situation is as desperate. Biologists think that ***large and complex systems can be interpreted on the basis of their components, but that they cannot be constructed on that basis***. The reason again is the imponderable, which is a very fascinating element in the evolution of systems. But the imponderable cannot be pondered. So I am grumbling, and I am asking you if you can solve the problem. My guess is that perhaps we should imitate what science did at the end of the Middle Ages when it transcended from the wish to interpret everything—from the origin of the world to the destiny of man—within a single system, to the much simpler and accessible level of learning how water flows in a pipe. Great success has come from specialization, and so the reduction of objectives to more manageable proportions can perhaps lead to more usable protocols for us on the consumer side.

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