A Review of Arnulf Grubler, "Technology and Global Change." Cambridge: Cambridge University Press, 1998. In cooperation with IIASA, The International Institute for Systems Analysis, Vienna, Austria. Hardback $49.95. ISBN: 0-521-59109-0

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There could not be a better book to review in this Journal. Indeed, the author himself is a contributor to TF&SC, as are many other people connected with IIASA. In fact, the title of the book might more properly be "Technology and Social Change" than "Global Change" because, though global (that is to say, global environmental) change certainly is discussed, it is by no means the main focus, on par with "technology." Instead, this is an impressively comprehensive book on what "technology" is, and how it serves as a major contributor to social and environmental change, as well as a "solution" to many of the problems caused by those very changes.

The breadth of the book is quite breathtaking and yet each topic is covered in equally-impressive detail. Moreover, while the author is clearly and enthusiastically "pro-technology", he nonetheless endeavors, generally successfully, to treat the genuinely complex issues fairly, and at no time does he ridicule or in any way disparage those who feel technology is always, or primarily, bad, or that technology has no positive role in solving the anthropogenic aspects of global change.

The book is in three parts, the first of which, in three chapters, is titled "What is Technology?" This section could easily stand on its own as an excellent introduction to technology and its role in human and environmental affairs. This part of the book should be especially appealing to people looking for a good text on this subject. I certainly will expect students in my futures courses to read it.

Part Two is composed of three separate chapters which discuss the historical and contemporary role of technology in agriculture, industries, and services, respectively. Part Three is a conclusion and an extended "postscript" which discusses various models of technological change.

The writing is clear and straight-forward, though perhaps a bit too plain and boring. While it may be unfair to expect an author who covers so many diverse topics in such extensive quantitative detail to also be an engaging writer, it would, nonetheless, help the reader who does, after all, need to follow a very complex and detailed historical argument.

An attractive feature of the text is the frequent use of sidebars to highlight certain aspects of the main narrative. One box, which emphasized that the famous Irish Potato Famine was a political, and not a technological failure, was quite informative, and one comparing the emissions of horses with automobiles was memorable indeed. A listing of the boxes in the table of contents would have been useful.

However, the book makes excellent use of many graphs, tables, and photographs. It features extra-reading suggestions at the end of each Part as well as a long bibliography and a (mostly) adequate index.

I did not notice any major errors or fatal omissions. But I naturally do have a few comments to make about what was and what was not discussed.

First of all, though there are some occasional forays into the future (concerning dematerialization, decarbonization, and "human liberation from the environment," a la Ausbel--which careful readers of the reviews in this Journal will remember having been discussed some issues ago), the book is more useful as an historical review than as a future guide.

Nonetheless, I am grateful for the volume as a potentially valuable aide for my own futures courses and research, since technology serves as the central key to my own understanding of things to come, and hence is the focal point of all my futures teaching and consulting for the past thirty years.

Though Grubler does not quote Marshall McLuhan on this, I do: "We shape our tools, and thereafter our tools shape us." Indeed, Grubler's analysis could have been much better sharpened as well as broadened to include communication technologies (which it presently does not), if he had included McLuhan's theory in his purview.

Nonetheless, I find most of the discussion in Part One, "What is Technology?" to be quite similar to what I believe, teach and use. I was pleased to see Grubler's distinction between hardware and software, but was amazed that he did not also introduce the concept "orgware" which I believe the cybernetisist Gennadi Dobrov coined in the early days of IIASA. I say this because, immediately after introducing the distinction between hardware and software, Grubler writes, "The two are interrelated and require both tangible and intangible settings in the form of spatial structures and organizations. Institutions, including governments, firms and markets, and social norms and attitudes, are especially important in

determining how systems for producing and using artifacts emerge and function" (p. 20). That is a very good description of "orgware," and I, for one, find it useful to spend as much time clarifying the role of orgware as I do of hardware and software.

In addition, since Grubler does spend so much time making definitions and distinctions, it would have contributed a lot towards the reader's understanding of the later substantive material if he had used these definitions in some systematic way while discussing agriculture, industry and services. From time to time, usually as a footnote or aside, Grubler does comment that such and such is an example of "path dependency" or some other previously-discussed term, but his definitions do not play the central explanatory and analytic role which their laborious elaboration early on implies they will and should.

Perhaps because I have only recently capitulated to Kondratieff Long Wave Theory, pretty much against my will, I was amazed that, in Chapter Three, titled, "Technology: Models," there was no mention at all, and certainly no lengthy discussion, of Kondratieff's theory and models, even if only to dismiss them. I did not encounter discussion of them elsewhere in the book, though I did see one citation of Kondtratieff's work, and several by his contemporary followers, in the bibliography.

My biggest concern is that, inspite of the comprehensive nature of this volume, and especially considering the alleged concern about global change, and in light of his discussion about context and supporting institutions (that is, "orgware"), there was no discussion at all of the role of either the military or the global capitalist system. While Grubler makes it clear that technology is not "autonomous", he utterly ignores the two most powerful of all catalysts for new technologies and their use.

It is true that, early on, Grubler says he does not intend to say much about the policy implications of his research, partly because he feels we have been very unsuccessful in assessing the impacts of technology when we have tried to do so previously.

This strikes me as a thoroughly disingenuous comment. To the contrary, I would argue, we need to try to learn from our past mistakes. Or else why write the book? We need more and better historical surveys of the impact of technology on society and the environment; better understanding of what "technology" and its related factors really are and how they have played out historically; better models, perhaps not all formal and quantitative, which we do in fact test over and over again in order,

ultimately, to be able to make some useful policy suggestions about technology before it is diffused.

Nonetheless, even if we were to have perfect technical capability to engage in technological forecasting and assessment, as long as we have institutions such as global capitalism, with its handmaidens (a stockmarket and fiscal system largely uncoupled from the production and sales of goods and services; widely-used economic indicators, such as GNP, which proudly do not distinguish "good" activities from "bad" ones, as well as ever more seductive advertising systems which create more and more "demand" on the one hand, and ever more future-stealing schemes for consumer and corporate indebtedness which create more and more "effective demand" on the other), technology does appear to be autonomous, and leading to global environmental catastrophe no matter what might be technologically feasible and humanly/environmentally preferable.

It is not technology which is autonomous. It is the actual economic system (hiding behind the shibboleth of a "free market") and the willingness of essentially all nations to spend orders of magnitude more on studying, preparing for and practicing war than on studying, preparing for and practicing peace which is out of control. Hence we are unable quickly and effectively to anticipate global change and to invent and diffuse technologies which can help us prevent or ameliorate it.

When Grubler writes the book which combines what he has done for technology here with what needs to be done for the orgware of economics and the military in similar dispassionate detail, then he will have written the book that future generations have been waiting and praying for.

This volume tells part of the story very well. I hope he will carry on with the rest of the task.