Beyond the empirical turn:

responsible technology

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1. Relation philosophy of technology and general philosophy

When philosophy of technology first appeared at the beginning of the twentieth century, its practitioners did not devote much effort to the structural analysis of modern technology. Their aim at that time was primarily to defend technology as an independent segment of culture. They wanted to break the domination of science and economics over technology, and they rejected the idea that technology is simply neutral. Furthermore, because of the stormy development of modern technology, it was not until later that the philosophy of technology began to concentrate on the significance of technology for culture as a whole.

Engineers share the responsibility for the absence of any structural analysis of modern technology during the period in which philosophy of technology was emerging. The engineers, deeply involved in the practice of technology, had so little interest in philosophy that they made almost no positive contribution to such an analysis. Besides, the lack of philosophical knowledge among engineers led all too easily to an overestimation of the role of technology on their part. More often than not, technological progress filled people with grand expectations for the future development of culture.

We must not forget that the general philosophy -- as an ontology or kosmology --, in turn, paid very little attention to technology. It underestimated the significance of technology at first, and for the sake of convenience reduced it to a science or regarded it as a neutral tool in people's hands. Philosophers were unfamiliar with technology; they lacked a basic empirical knowledge of it.

Eventually, because of its enormous influence on all of culture, technology could no longer be disregarded. Only then did general philosophy begin to take notice of it. Nevertheless, because of the current widespread lack of a thorough knowledge of technology in our society, technology is still being disparaged as a dangerous power threatening human welfare. Technology is all too quickly blamed for the cultural crisis. Inherent in this negative appraisal is an idea which is also shared by the optimists who view progress in positive terms - the idea that technology is all-embracing and all-dominating. The optimistic and pessimistic views both lack an adequate perspective on technology. While the one view overestimates the cultural influence of technolopgy, the other fails to appreciate the possibilities it offers.

A knowledge of technology and philosophy in their mutual interaction is essential to any effort to arrive at a structural analysis of modern technology. In the past, unfortunately, there was a great lack of communication between engineers and philosophers."Their respective terminologies and the origins and orientations of their thought are a disparate that a consensus on problems of mutual interests becomes possible only through extraordinary effort and with much good will." *(1)*

When weighing the beginnings of the philosophy of technology then, we must take into account the serious difficulties it originally faced. General philosophy virtually ignored the impressive phenomenon of technology and scarcely reserved a place for it. Philosophy of technology lacked a general framework. As a result, it developed almost completely independently of general philosophy. Engineers who had a philosophical interest in technology and its development but had uneven background in philosophy (or none at all) arrived at philoso-phies of technology, most of which can only be regarded as pseudophilosophical.

The proper task of general philosophy is to express the unity-in-diversity of total reality. By neglecting or overestimating technology as a disastrous power, general philosophy failed to do justice to the diversity of reality and thereby damaged its own insight into the whole of reality. Philosophy of technology, in turn, must take full account of the fact that it cannot be developed correctly outside an appropriate general framewordk. Philosophy of technology deals with only one segment of culture. Its field of investigation is limited. Therefore it must be able to call upon general philosophy to account for the coherence of technology and reality as a whole. General philosophy, for example, should account for the significance of technology for culture. The fact that dynamic development has made technology a prominent cultural force renders it all the more important for the philosophy of technology to be able to appeal to general philosophy.

A philosophy of technology set within the framework of a general philosophy should provide insight into the rich diversity of technological objects, the designing process, the technological products and means of production, and of technological activities, all of which are increasing in variety. I agree fully with Mitcham and Kroes that philosophers should pay more attention "to what really goes on in engineering and technology", and that a philosophy of technology ought to be "an empirically informed philosophy of technology" *(2)*.

2. Philosophical analysis of the structure of modern technology

A structural analysis of technology ought to define clearly both the potentialities and the limitations of technology, thereby obviating and guarding against misconceptions and false expectations concerning it. It ought to be related to the empirical practice of technology. All technological problems and all norms for technological development to promote responsible technology should be analyzed. In particular, a clear view is needed of both the relation between technology and science and the many cultural changes which their modern alliance has brought about.

Only with the aid of such a structural analysis does it become possible to deal philosophically with the cultural influence of technology. By giving prior attention to such an analysis, we can greatly reduce the danger of becoming too speculative about both the positive and the negative influence of technology on culture. We ought to go from a philosophy of technology to a cultural philosophy of technology, in stead the other way around as usually is done.

A structural analysis of modern technology within a general philosophy has taken place within a special tradition of dutch philosophy. This philosophy has not received that attention it deserves. The main reason of it is that it is developed as a christian philosophy and that generally speaking philosophers are not interested in such an approach. But it is worthwhile to give attention to the empirical and comprehensive approach of technology within that philosophy.

It is the Amsterdam school of reformational philosophy, which has also been called the philosophy of the cosmonomic idea *(3)*, which has developed a general philosophy within which technology may be dealt with. Because it provides a suitable place for the philosophy of technology, it can be used as a framework for analyzing the diversity of technology as well as exploring the significance of technology within the whole of reality -- especially the significance of technology for special sectors of culture.

Hendrik Van Riessen -- an engineer in electronics -- has already in 1947 began to develop a philosophy of technology within the framework of the reformational philosophy. He made benefit at the same time from what other philosophers have noted about the structure of technology. In giving his analysis of technology Van Riessen refers to a great number of examples from practical technology. In that sense he can be seen as the first philosopher of the empirical turn *(4)*. But more can be said.

A requisite of a structural analysis of technology is a good definition which refers to the empiricism or practice. Mostly philosophers who are claiming an empirical turn are not giving a sharp definition of technology *(5)*. The same omission can be found in the circles of the socalled classical philosphy of technology. For instance Heidegger and Ellul are not giving a sharp definition. I will define technology as the activity by which people give form to nature for human ends, with the aid of tools. In modern technology the tool is developed in computers, robots and even automatic factories.

Of course, the structural analysis of technolgy gives an insight in the development of tools, in the technological form-giving and in the designingprocess. In giving attention to the basic structure of moderen technology we get a general overview of it.

3. Basic structure of modern technology

The grand quest in modern technology has been to develop technological objects -- tools -- that can operate independently. To this end, human proficiency in forming is projected into and transferred to the technological object. A transfer of the decision-making capacity pertaining to the sequence of the activities of forming also occurs. By means of automatic switches, people make provision for the technological forming process to undergo discontinuous changes with the passage of time.

Taken together, the projection of proficiency, the transfer of "decisions", and the use of formed energy constitute the foundation of the independent operation of modern panoply of tools and instruments. This panoply is composed of what sometimes is called technological operators. Apart from design and installation, people need only give a command to set the technological operator going.

The "proficiency" of the technological operator surpasses that of human beings in speed, reliability, and accuracy. Even mechanical "decisions' are realized more quickly and faultlessly than "decisions" made and implemented by people. And the power of formed energy far exceeds human power. Now, what all this means is that people equipped with technological operators can accomplish a great deal more than people without them. Moreover, there are more recently created technological operators that work in ways that bear little or no resemblance to human actiivity. Electrotechnology and chemical technology offer examples of such a development.

The development of technological objects are sketched here, namely, the realization of independent operation, has been made possible only by the scientific foundation and scientific method of designing.

Through the scientific approach of modern technology, a distinction has arisen between preparation (designing) and execution (technological forming). Human responsibility and decision-making have been transferred to the phase of preparation, and the human activity of designing has thereby come to occupy a higher place. There has in fact been an intellectualization of technological labor. Preparation along the lines of the technological-scientific method leads to the accomplishment of a design for execution; this design is complemented by the independent operation of the technological panoply. As a result, human power in the phase of execution is enormously increased.

I summarize the basic structure of modern technololy as follows: the basic structure of modern technology is characteristized by the technological operator, the scientific foundation, and the technological-scientific method. *(6)*

At this stage it is necessary to note that even in modern times, technological activity is and remains a human activity. This fact is decisive for proper insight into the limitations and possibilities of technology. One must never lose sight of the intimate connection between people and technology, especially when evaluating such a phenomenon as automation, which may sometimes appear to be rather autonomous with regard to people. In fact, the intimate connection between people and technology is crucial if we are to resist arguments to the effect that technology as a whole is autonomous *(7)*. That menas that technological development is deterministic. This 'autonomy of technology' has recently caused 'the empirical turn' in philosophical circles to make clear that the design process is not deterministic *(8)*. In my view we have to go beyond that turn to a responsible technology *(9)*. To make that clear we are looking more precisely to the design process and to responsibility in designing.

4. Philosophy of design

We have seen already that technology involves two stages of design and fabrication, closely linked as two interacting parts of the production process. They are also linked by the fact that the fabricating facilities and procedures are themselves the result of a design activity. It is necessary to give more attention to the design activity.

Design is that structured, innovative activity whereby people creatively use theoretical and practical knowledge and available energy and materials in order to specify the size, shape, function, and material content of a technological object. So designs not only depends upon theoretical and practical knowledge but also on the availibility of energy and materials. It assumes the existence of the physical reality, and utilizes both knowledge and available energy and materials in its activity. Design results in a blueprint or set of detailed instructions for the physical characteristics of a technological object-- either a product or a tool.

It should be noted that although the design process is a structured activity, it is rarely if ever carried out in a rigid, linear way. One step does not follow another in lockstep fashion until the tool or product "automatically" emerges. Feedback plays an important part in the process. The results of one step -- for example, certain design specifications -- may lead to changes in prior steps, such as redefining an identified need. Furthermore, this kind of structured thinking about design may enhance rather than inhibit creativity in that it more clearly focuses people's attention on the broad range of task that must be accomplished.

Although designing is dominated by the scientific design method (see next paragraph), which guarantees the continuity in technological development, we must attend to breaks in this continuity. We are talking about inventions. Technology continues to develop in the context of scientific consultation and formulation. In ways that are often unexpected and cannot be simulated, productive imagination can put people on the track of technological innovation. These innovations can interrupt the developmental process of technology and it is a clear evidence that technology is not autonomous.

In modern technology, invention takes place at a higher level than in classical technology. Today inventions build on mathematics, physics, information theory, and technology as science. This also means that when inventors are onto something new in technology, they try to develop it scientifically and to check it out with precision instruments to complete the invention. But at the decisive moment of inventing, theory plays no role. The invention and its effects will later belong to the field of technological science, which also served as its basis. This being so, the invention contributes an additional path to those presently available for new technological possibilities *(10)*. And such interventions give new possibilities for responsibility in design (see the last paragraph).

In recent discussions about 'the empirical turn' it seems that attention is given to individuals doing design in a few specific industries and then analyze their work in detail. This method would certainly lend itself to an explication of some of the details of design. The problem with this approach, however, is that one would tend to accumulate mountains of information about specific design activities, but only slowly - if at all -- uncover the basic patterns present in design activity. Also, making design decisions and doing the actual work of designing -- even within a specific design project -- are tasks usually performed by many persons, and thus an enormous number of individual activities would be need to be considered in detail before patterns useful for analysis would emerge. This method of analysis, which may have its place within a given industry, ends up being somewhat akin to studying a forest by studying the individual trees.

A better method -- the one I like to follow -- analyzes general patterns of design. This broader approach is helpful both to general public, who need understand technology better, and to the decision makers within design activity, who need an overall perspective on their work. To achieve this broader approach, it is helpful to emply what Hans Lenk and Gunter Ropohl (following Max Weber) refer to as an "ideal type" analysis of design *(11)*. Instead of making a close scrutiny of a few individual efforts, this approach involves observing the design activity from some distance so that overall patterns can be seen more clearly. This approach takes a general perspective on the design activity based on an amalgamation of a wide range of experiences and analysis of design. It has to do with the concept of design, not with individual design activities. A method related to individual design belongs to the history of technology or sociology of technology, not to a philosophy of technology, i.c. philosophy of design.

To a broad picture of design belongs a general analysis of the method of design, which is a scientific one. And this scientific method implies an holistic approach. Holism is the view that the integrated whole of a technological object has a reality independent of and greater than both the sum of its parts and its particular function. Every technological object or product is experienced as a unity.

The case for a holistic approach to design rests primarily on the fact that the technological tools and products produced by design and production enter everyday experience as unities. This being the case, design itself should be holistic. Indeed, people's lives are affected not by technological objects per se, but how these objects function in all aspects of reality. A car can not only conforms to the laws of physics and chemistry, but is also an object of proud ownership, has a value relative to that of alternate purchases, and is a focus of trust, because the buyer believes that if it is used correctly, it will not be harmful. If an object is to function well in all of its aspects, they must be taken into account in its design. And that is what holistic design seeks to do. The design of technological objects must take the diversity of reality into account if those objects are to function well.

Holistic design of this nature involves making value judgements in all of the various aspects of reality. Taking these value judgements into account in designing is the creative challenge for the designer. But is this enough? Does holism provide sufficient content for a design philosophy? One only has to image a horrific product -- a gas chamber for the wholesale murder of innocent victioms that is "well-designed" and "functional" in all aspect of reality (at least from the viewpoint of a Hitler) -- to realize that a proper design philosophy requires something more than holism. One still must determine what normative principles should be followed in the practice of holistic design.

But before dealing with the value-ladeness of technology, I would like to describe in the next paragraph the general scientific method which is used in the process of design and which characterizes the technological objects for a great deal.

5. Scientific design method

In designing the modern engineer is using the scientific method. To understand this method and the influence of this method in relation to technological operators or tools and products it is necessary to give more attention to it.

The scientific method in designing is like that of the natural sciences, but is technological because it focuses on the design of technological things or processes. This scientific design method characterizes modern technology. As a result, the features or characteristics of science are projected in technology. Seeing this close intertwinement of science and technology also helps us see the characteristics of modern technology *(12)*.

Within the scientific method of the natural sciences we attempt to discover universal knowledge of reality. With the scientific design method we intend to formulate technological designs both for the product and for producing it. The ultimate aim is a temporally and spatially remote, scientific control of the individual technological process of forming or producing. But its result also belongs to the domain of technological science because the designs furnish us with knowledge regarding technology. Thus, physics is related to universal knowledge of the physical aspect of reality, technology as science is related to knowledge of technological objects as a whole *(13)*.

Some of the characteristics of natural scientific knowledge and of its method are reflected in a technological kind of way in technoloigal science. This is in large part due to the scientific basis of design. These characteristics can also be found in the technological production process and its results.

Analysis, abstraction, logical synthesis constitute the method of science. That is to say, in science we consciously turn away from and seek to avoid the influence of the immediaces of the concrete individual, situation, or environment. As a result, scientific knowledge is universal, enduring, logical coherent and functional, abstract knowledge.

The engineer, too, follows the same procedure. The technical question is broken down into parts which in turn are posed as universal (sub-)problems. Universal modular solutions are sought both for the components of the thing to be produced and for the steps of the production process. The division of functions continues until one has arrived at atomized, isolated, autonomous functions.

Analysis puts technological modular functions at one's disposal. Abstraction presents each of these functions on its own, bracketing out the others, so as to find a technological solution for that subfunction. The result consists of basic building blocks that have a standardized neutrality of purpose about them and and, hence, can have a universal appication in technology, as is the case for example with propellers, rivets, or dovetail joints.In this universal applicability, a result of analysis and abstraction, we find science's general or universal knwoledge projected in technology. In other words, the universal suitability of the solution of a subfunction is an analogy of scientific knowledge in technology.

In addition to the neutralizing division of functions, the scientific design method, as was said, also aims at a spatially and temporally remote control of the process. Therefore, the tool or technical operator must be constant over the course of time. The control of technological formation at a distance and over times is an analogy of science as enduring abstract knowledge of reality.

This remote control, with respect to the whole, is further made possible by the integration of the neutral modular solutions. Depending on the modules that are merged, this integration of functions can represent many forms of individuality. As such, it is a technological analogy of the synthesis in science. The scientific design method aims than, on the one hand, to standardize how functions are divided and, on the other, to anticipate how these functions will be integrated for various specific ends. The production process that results is likewise an analogy of the coherence of scientific knowledge, with the product of mass production showing something akin to the universal character of scientific knowledge.

In like manner, an analogy of scientific abstraction can be noted in the integration of the solutions from each module. These problem sets were originally isolated by means of abstraction. After a standardized solution is found for each subset, the integration of these separate solutions requires that technological formation take place elsewhere, in isolation. Pertinent measures are taken with that in mind. Technological formation has an enduring character about it because influence from the surroundings, like tempererature and humidity, are precluded as much as possible.

This scientific design method determines the basic structure of modern technology. Technological science and technology are virtually interwoven.

When developments in science lead to a new method, as was the case with systems analysis, then this method recurs analogously at the technological level. That is why general systems theory and computer technology are complementary.

Although the influence of science on technology is legitimate, when science is used in technology under the influence of power technology goes on the way of irresponsible technology, the design process becomes deterministic. We can also say that technology becomes autonomous technology. Then there is no place for normative principles in designing technology. And the normative principles ought to be at the heart of responsible design. A scientized tunnel vision in design and fabrication prevents one from asking questions of justice, stewardship, and cultural appropriateness. But when science and its methodologies are put in their proper place, holism can be practiced and normative principles can be given their dure. Technology is then freed to be practiced responsibly.

6. Responsible design

In paragraph 4 I have argued that technology is necessarily and intrinsically value-laden. The question is important which normative standards in technology ought to be obeyed.

As we have seen already, holistic design is important, but it needs to be undergirded by normative principles that take into account all to the aspects of reality within which the technological object is to function. I will restrict myself in dealing with headlines of the normative principles.

The basis of every technological development is that technology ought to be ecologically adaptable. This starting point is preventing that technology causes ecological disruption. Next, the disclosure of the technological development should be guided by eight *(14)* normative principles. Even though I will discuss these normative principles individually, they are to be followed simultaneously, not in isolation from each other.

Cultural Appropriateness. All those involved with design must make sure that their designing results in culturally appropriate technological objects. This means making appropriate decisions in relation to the five sets of opposites of the cultural-historical normprinciple: continuity and discontinuity, differentiation and integration, centralization and decentralization, uniformity and pluriformity, and large scale and small scale. Those involved in design must not design technological objects that totally embrace one or the other of each of these five pairs of opposites, nor should they simply strike a balance between them *(15)*. This normprinciple is not simply one of accomodation to anything that works in a given cultural setting. Important cultural manifestations should not be destroyed by an intrusive technological object. Indeed, the culturally appropriate tool or product is one that alleviates human burdens and preserves what is wholesome and good in a given culture. In this way it strikes an appropriate balance between continuity and discontinuity.

It is also important to balance the opposites of centralization and decentralization. Should our culture be more centralized and homogeneous or more decentralized and heterogeneous? Those involved in design should consider such matters of balance in following the normative principle of cultural appropriateness.

Openess and Communication. Openess means that we must clearly inform society about technological renovations. Only then can those working with the technology or purchasing its products, responsibly evaluate things and make decisions. Uniting the normative principles of openness and communication results in the principle of open communication. Without open communication, it is impossible for those who participate in technology to fulfill their communal and individual responsibilities. Those who develop technology have the responsibility to take the time to inform and communicate with the public. Quite obviously, people in the technological sciences, in particular, have to honor these norms of information and communication for these are the ones who stand, as it were, at the cradle of every new technological development.

Stewardship: efficiency and sustainability. The economic norm of efficiency must also be honored, but not to the exclusion of the others. As it applies to technology we are talking here about the matter of efficiency. Its presently one-sided application is due especially to the prevailing influence of economic theory within industry. More than once industry has focussed fat too narrowly on a natural scientific sense of efficiency, in which only those goods that can be expressed in monetary terms determine what has value. We must integrate the economic norm into an integral framework of norms. We must apply it not only to production, but to the use of raw materials, energy, nature, the environment, landscapes, animals, and even of the people involved in developing technology. Problems arise when we limit the economic norm of efficiency exclusively to techniques of production. Technology and the economics of industry develop into a jumble. But when we apply the economic norms of efficiency and sustainability, in conjunction with the other norms, simultaneously across the board, we can prevent a kind over overdevelopment in producing surpluses and restore a kind of underdevelopment in being stewardly in dealing with nature. We will begin to attend more to nature and to the environment, to the scarcity of raw material and energy, and therefore to honor sustainability. Besides, we will come to see that people are much more than their ability to function economically within a technological context. We must acknowledge the responsibility of employer and employee.

Harmony. The normative development of technology is advanced when we abide by the norm of harmony. Non-essential surpluses, and the degradation of nature, make it abundantly clear that this norm is not being followed. If it were, given the other norms we have discussed, people would realize that technology ought to be developed in a balanced mannere. This norm also requires that we introduce and incorporate new technology not in a revolutionary fashion, to prevent societal unrest and a loss of communal support. We must also consider this norm of harmony in the multifaceted interrelationships between nature, people, culture and technology. Technology ought to adapt to people, not people to technology. For example, it is not without reason that we appreciate user-friendly tools. That is the way all tools should function. When that is the case those who operate them will also have greater pleasure in doing so.

Justice. In honoring the normative principle of justice we oppose any and all injustice that the development of technology may bring about. Engineers, instructors, and employees must ask themselves whether their contribution to technology does justice to the plant and animal kingdom, to our sources for raw materials, to consumers, to society, to culture, to third world countries, and the like. This norm of justice is an intrinsic part of technology. When it is disregarded, the government must take specific measures to restore justice. It is worth emphasizing that the positive influence of technological developemts that obey this norm will also be felt in the many sectors of society in which technology is playing an increasingly important role. That is especially true, for example, in modern agriculture and in health care.

Care and love. All the norms indicated above are opened up and deepened when people hold themselves to the ethical norm of care and love. We are called upon to nurture a concern and compassion for everything that has to do with technology. This, of course, includes caring for and loving our neighbors, far off and close by, but also protecting the great diversity of all other creatures. When love binds itself only to scientific-technologicasl control, people become so obsessed with control that it is frightening. When this norm is not honored on all sides, people become more and more alienated from their work, for example the farmer from the land, nature, and his animals.

Trust. The last norm to which designing is subject is the norm of trust. Those who use the tools of technology have to be able to trust that these tools work and are safe. When this norm is met, they will be. Or more broadly, when people accept and operate according to the framework of norm principles sketched above, technology will be safe. When all the normative principles will be followed, technological design will be truly responsible. *(16)*.

Notes:

1.Klaus Tuchel, Die Philosophie der Technik bei Friedrich Dessauer: Ihre Entwicklung, Motive und Grenzen, Frankfurt, Knecht, 1964, p.15.
2. See Carl Mitcham, Thinking through technology, Chicago: University of Chicago press, 1994,p.ix.
3.I refer here to a school of philosophy developed at the Free University in Amsterdam in the 1930s by Professors D.H.T. Vollenhoven and H. Dooyweerd. See H. Dooyeweerd, A New Critique of Theoretical Thought, 4 volumes, Amsterdam/Philadelphia, 1953-1958.
4. See H. van Riessen, Philosophy and Technology (in dutch), Kok, Kampen, 1947. see in english Egbert Schuurman, Technology and the Future -- a Philosophical Challenge, Wedge, Toronto, 1980, p. 1-50, and Egbert Schuurman, Perspectives on Technology and Culture, Dordt Press, Sioux Center, Iowa, 1995, p.1-70. Recently in The Netherlands is given new attention to Van Riessen's philosophy of technology by Hans Haaksma: Van Riessen:philosopher of technology (in dutch), DAMON,1999.
5. A.Rip in Technologie en samenleving, Leuven-Apeldoorn, Garant, 1995, says for instance that technology is so complex that it is not needed to make precise distinctions

(p.10, 15). I would stress that given the complexity of technology it is needed to define what technology is all about.
6. See E. Schuurman, Technology and the Future, p.8-24.
7 See J. Ellul, The Technological Society, London, 1965, p.14, 128, 134, and The Technological System, New York, 1980, p.125 vv.
8 See recently: Andrew Feenberg, Questioning Technology, London/ New York: Routledge press, 1999, p. 76.
9. See Stephen V.Momsma (ed), Responsible Technology, Eerdmans, Grand Rapids, 1986, p.165 vv.
10. see Friedrich Dessauer, Streit um die Technik, Frankfurt/Main, 1966, p. 167.
11.See Hans Lenk and Gunther Ropohl, "Towards an Interdisciplinary and Pragmatic Philosophy of Technology", in Research in Philosophy and Technology, vol.2, ed. Paul T. Durbin and Carl Mitcham, Greenwich, Jai Press, 1979, p.32.
12. See E. Schuurman, Filosofie van de Technische Wetenschappen, Martinus Nijhoff, Leiden, 1990, p.51-57; E. Schuurman, Perspectives on Technology and Culture, Potchefstroom, Zuid Afrika/Dordt Press, Sioux Centre, U.S.A.,1995, p.44-51.
13. This implies a problem; see: The limits of the scientific design method, and the relation of physics to technological science, in E. Schuurman, Technology and the Future, p.25-31, 41.
14. See for more explanantion: Stephen V. Momsma(ed), Responsible Technology, Eerdmans, grand Rapids, USA, Chapter V: "A guide to responsible technology", p.58-76.
15. See Victor Papanek, Design for the Real World: Human Ecology and Social Change, New York, Bantam Books, 1973,p.34.
16. See also E. Schuurman, Science and technology as religion? Hope for the Future (Forthcoming).

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