

USE OF ECO-EFFICIENCY INDICATORS IN TECHNOLOGY DEVELOPMENT FOR INDUSTRIALIZATION, MODERNIZATION AND SUSTAINABLE DEVELOPMENT IN VIETNAM

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Abstract:

In the process of technological development for life and production, eco-efficiency indicators should be applied to control the use of natural resources before or after they are integrated into products. Eco-efficiency indicators in new technological development is an important aspect but it has little been mentioned in documentations on technology management in the country and abroad. Based on qualitative analysis of the technological development process, this article presents basic features of the use of eco-efficiency indicators in the process of technology development in three different stages: First, planning stage of a technology; Second, the stage before the development of technology; and Third, stage of technology transfer. The goal of this study is to provide some proposals for the use of eco-efficiency indicators in the process of technological development, as well as in the appraisal of technology development projects.

Keywords: *Eco-efficiency indicators; Technological development; Industrialization, Modernization; Sustainable development.*

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Introduction

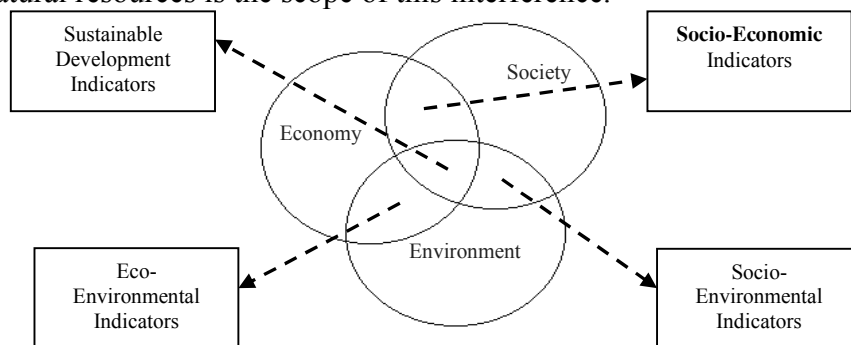
Technological development implies the development of technical skills, machinery and equipment which constitute a basic element for promoting innovation in production. This makes the technology enter the market with products or services that it generates. However, besides the necessity of technological innovation promotion, limited use of natural resources brings a lot of challenges to the process of technological innovation. In addition, by direct observation, environmental pollution mainly comes from manufacturing processes. In the eyes of scientists, technology is the root cause and also the solution of environmental problems [1,4], this requires technological innovation and production managers to foresee environmental impacts. In our country, the State only demands that technology development and technology import should be eco-efficient as much as possible. In essence, effective production and natural resources consumption must be carefully considered along with environmental assurance. Some

studies on characteristics of the ecosystem and its relation with technology development level have been published recently [3,6,7]. However, the authors of such studies did not demonstrate the connection of production activities with ecological aspects. Meanwhile, eco-efficiency is a necessary element that should be seriously taken into account by the State, businessmen and technologists of our country. The formulation research and technology development strategy of scientific and technological organizations and production enterprises is not only for economic effectiveness but also for environment protection and rational use of natural resources in the economic - environmental - social interrelationship.

In this study, the author analyzed the aspects related to the use of eco-efficiency indicators in technology development process with a view to identify the possibility of using such indicators in a proposed theoretical process, contribute to the sustainable environment management. The next section presents different aspects of eco-efficiency indicators relevant to the process of new technology development.

What is eco-efficiency indicator?

According to Ayres and Miller (1980), eco-efficiency indicator is the management capacity of an organization in the conversion of natural resources into goods or services towards meeting the requirements of consumers [2]. This is seen under two technological aspects, as follows: First, producing the same amount of outputs with fewer resources; Second, producing more outputs with the same amount of resources. The use of high eco-efficiency technology in production strategy needs to be placed in the relation with environment, in which, the term "sustainability" is the centre in the Society-Economy-Environment interference model (see Figure 1). Eco-efficiency of technology development process, especially the effective use of natural resources is the scope of this interference.



Source: [2]

Figure 1. Multidimensional interference model of sustainable development indicators

Measurement of technology by eco-efficiency based on the use of ecological indicators was launched by Figge and Hahn in 2005 [4], whereby it clearly identified opportunity cost from the use of natural resources. With the selection of tools and methods to assess the environmental sustainability, businesses need to use eco-efficiency indicators to look for better opportunities based on the point of view "what can be measured, can be managed". These indicators will help businesses review or eliminate much resources consumption technologies. Appropriate environmental aspects will create a technology measurement system (see Table 1).

In Table 1, the majority of indicators are proposed to measure environment in every stage of product unit and assess business processes. For example, if there were losses or waste of natural resources in the production process it would very likely relate to effective technology management.

According to study by Labuschagne and Brent (2005) [5], the authors set sustainable development indicators for a technology to be implemented in production, by examining the product life and the project cycle. According to the authors, the use of efficient indicators in developing new technologies is an important tool when making decision on whether to apply it in production or development of new technology.

Table 1: The efficiency indicators determined in relation to the environment

Environmental aspects	Environmental efficiency indicators
Raw materials	Volume of raw materials consumed by a product unit or volume of materials recycled, reused.
Energy	Amount of energy consumed per year, per product unit or the amount of energy saved by improvement programs
Emissions	Volume of specific gas emissions per year or per product unit
Water	Volume of waste-water per product unit or water consumed by product unit.
Noise and radiation	Noise and radiation of the warmth, vibration, light, noise emitted per product unit
Toxic materials	Volume of toxic materials from hazardous wastes controlled by permits or hazardous wastes eliminated by replaced materials
Land use	Amount of money for land use or affected land, amount of protected or rehabilitated land

(Source: Figge and Hahn launched in 2005)

Process of technology development

Technological development process is considered as activities and decisions to transform knowledge and ideas into tangible object. For example, the technology attached to equipment, machinery, or technology embedded in intangible assets placed in a production process will create favorable conditions for the development of new products. In addition to technological factor, practical activities combined with management decisions is a necessary requirement to create a process of developing a complete technology. One of the ways to improve the efficiency of technological development process is improved structure of the production and business process, this means the way of management and organizational structure can help businesses or scientific organizations make effort in technological innovation like developing a literature work. In reality, it is necessary to separate the process of technological development with the process of product development for the support to be effective and the reform of these processes be of success. To better understand the process of technological development, this paper presents the ideas in a generalized model showing 6 phases and the key points, as bellows (see Figure 2).

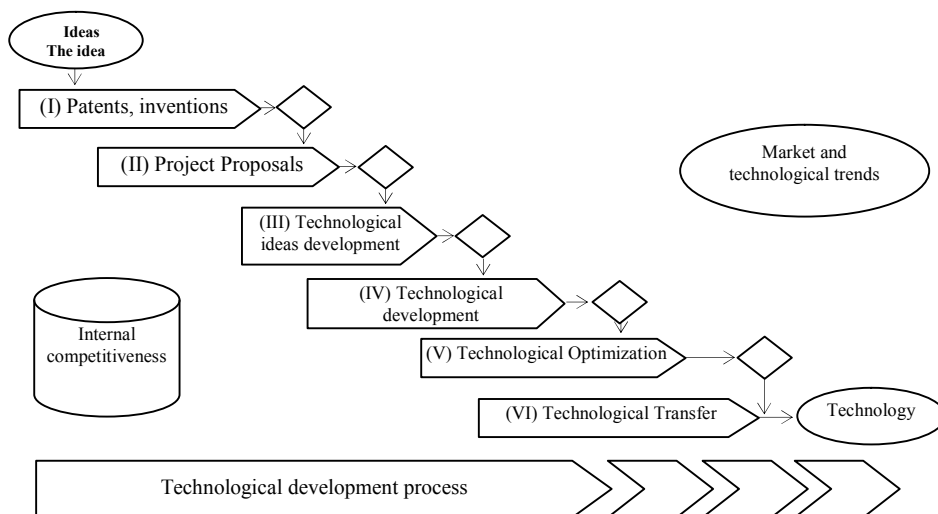


Figure 2: Theoretical model “Technological development process”

In Figure 2, the model "technological development process" with 6 different stages from business and technology ideas to need identification of new technological development, through activities of technology testing and technology transfer to develop products. The process of technological development within an organization associated with market and trend of new technological development, it includes the following stages:

Stage I. Patent: Identification of the enterprise's strategy, technology strategic exploitation, types of technology, consumer's needs (market research), developing ideas.

Stage II. Project scope: Scale up the scope of project, mapping future plans, conducting literature study, patent searches, identifying opportunities.

Stage III. Technological ideas development: Identification of potential ideas in certain conditions by preliminary experiments, identifying necessary resources and solutions for implementation, product base design, the way how to create a technology (technology needs), conducting standardization of existing technology, developing a network of partners, identifying features of the new technology, determining the impact of new technology, analyzing documents and creation of technology branches.

Stage IV. Technological development: Selection and development of technology, identifying potential commercial products and processes, system function divided into main functions, defining system architecture, use mathematic model to express ideal functions of technology, prototype development and testing, determining the impact of market and production, preparation for the implementation of business plans, identification and evaluation of important parameters.

Stage V. Optimization of technology: Technology optimization from its important parameters, analyzing factors that can lead to development of branch systems based on key technologies, implementation and optimization of experiments, analyzing data obtained from the experimentation process.

Stage VI. Technology transfer: Designing a platform, integrated sub-systems, testing the efficiency of the system, setting technology selection criteria.

The process of technological development is a series of activities from scientific ideas to technology transfer with the aim to introduce new products to satisfy the human needs. For instance, the actual process of developing a complete technology associated with production at Honda Corporation (see Figure 3). So, it raises the question how to measure the efficiency of technology which use to assess the environmental sustainability? Can this activity define different stages in the technology development process by using the eco-efficiency indicators or not? If the above questions can be answered, the issues raised in this paper will be clarified and it will support leaders to decide whether or not the development of new technologies be associated with eco-efficiency.

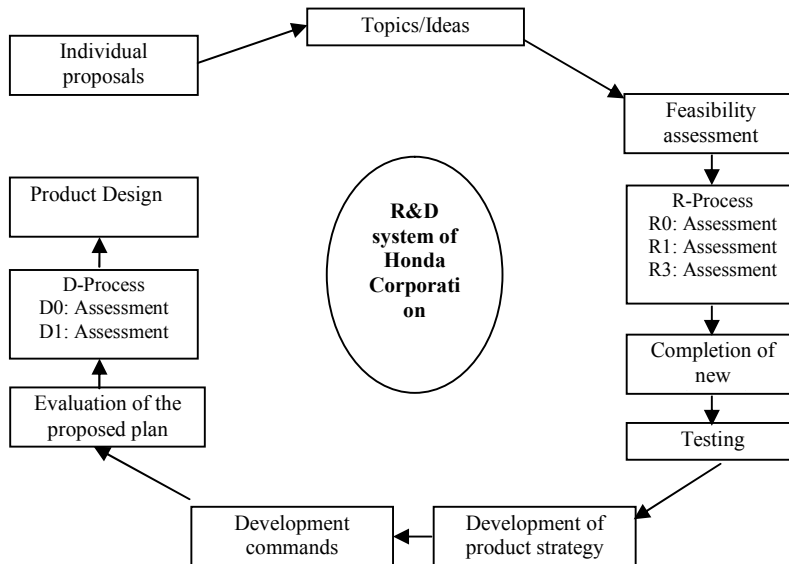


Figure 3: The process of completed technological development for production of Honda Corporation

To simplify the chain of activities in the Model (Figure 2), a diagram followed the technological development process is drawn and divided into three different stages (see Figure 4): The initial stage, formulation of technological development plan, may last for a few months; The intermediate stage, technological development, may last for many years, and The final stage, technology transfer, may take some period of time to develop into product. Within the above stages, there are interspersed decisions whether to further develop the technology or go back to research step for further study.

From an innovation focused technology strategy, the technological development process begins with the formulation of technological development plan, in which include phase (I), (II) and (III) of the technological development model relating to invention, project scope and technology development direction. In this segment, scientific organizations or production entities should select core technologies which are appropriate to their capacity. And then, the new technology is created. There are some decisions on technology development and R&D implementation for new technologies that the organization is looking forwards. It includes stage (IV): technological development and stage (V): technology optimization. In this period, sample testing and actual simulation experiments are conducted for necessary adjustments to optimize the development solution. Finally, in

the technology transfer process, referring to the stage (VI) of the technological development process, different systems are integrated into the system and determine standards for the technology.

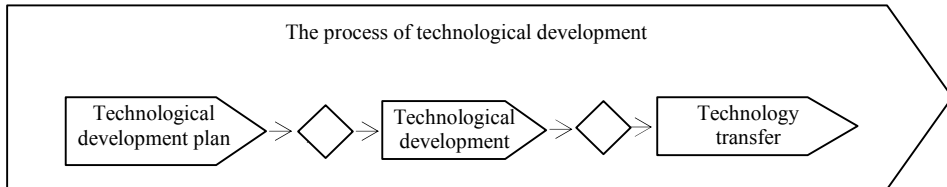


Figure 4: Three-stage diagram relating to the use of eco-efficiency indicators

Proposal for the use of eco-efficiency indicators in technology management

The main purpose of the above analysis was to examine the use of eco-efficiency indicators in three different stages (technological development planning, technology development, and technology transfer) in order to improve the quality of decisions by leaders or managers of technology concerned.

Table 2. Use of eco-efficiency indicators in making decision on technology development

Utility	Description
Comparison standards	To compare the implementation process with similar characteristics to identify opportunities for improvement.
Frequency of use	To measure the progress along with the time.
Technology appraisal	A set of indicators to support for decision-making, selection of new production process.
Inputs assessment	Inputs of the production process are of the greatest impact on the environment.
Technology assessment	The indicators can be used to assess equipment and technology.
Different indicators	To provide information in support for decision-making.

This paper proposed the application of eco-efficiency indicators in the technology development process as presented in Table 2, these indicators can be used to examine the eco-efficiency of a specific technology. It can be a product or technology. In case it is a completely new technology, when

determining the possibility of using eco-efficiency indicators it should directly relate to each stage in a specific period of time. Basically, it is as follows:

1. *For the stage of technological development planning*, a set of indicators for ecological conservation strategies, setting targets of natural resources consumption. In this role, the new technology must be tied to the environmental indicators. The environmental indicators ensured by the technology should base on existing technology indicators, and be used to more clearly demonstrate the expected technological objectives. Results achieved can reduce waste of resources and focus more on the effective development of the eco-technological components.
2. *For the stage of technology development*, as shown in Figure 3, eco-efficient technologies can be identified in the course of empirical exercise. It is to prove the consumption level of resources as well as desired activities and identify prominent important parameters in the empirical process. In this period, optimization testing activities can be carried out to increase the eco-efficiency of the technology through actual operation conditions. Technology eco-efficiency indicators will certainly contribute to the optimization of technology.
3. *For the stage of technology transfer*, when the technology is identified, indicators will provide limits, standards and value of the technology. This can help managers use the information arising in the process of technology development and implementation for checking the technology targets. It should take the targets into deeper consideration in early stage of technology development process in service of the inspection process. Finally is technology formatting, dissemination and identification of new targets for future technologies.

Although this study refers to the use of eco-efficiency indicators in the process of technology development, it still needs to conduct many other studies to develop a comprehensive set of eco-efficiency indicators and it also depends on the technological level of specific sectors or areas. Therefore, this is recommended that eco-efficiency indicators be carefully considered and applied appropriately in the practical situation of Vietnam's science and technology.

Epilogue

This study suggests the development of a system of eco-efficiency indicators for a technological development and completion. The highest value of the set of eco-efficiency indicators is that it can be seen as a “green

filter” so as that a technology project before getting approval, it must go through a natural selection under the environmental angles. In the initial development objectives set in the technology planning stage, in the intermediate stage of technology development, as well as in the last stage of technology transfer, the technology selection should deal with effective ecology to enhance the ability of technology completion. If this can be done, it allows better management of technological innovation activities with focus on environmental protection and sustainable development. This study also identified the eco-efficiency indicators that will contribute to the development of “green technology”, “clean technology”./.

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