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A System of Development Technology and Its Applications in the Third World

by H. A. Havemann, Aachen*

Development technology will have a crucial role to play in the realization of the Third World's ambitious industrialization plans. Professor Havemann presents a system of development technologies which is expected to help in establishing appropriate organizational and research facilities.

An increased participation of the developing countries in the global industrial production is a widely accepted aim. According to the resolution of the Lima Conference of 1975 the Third World's share in the global industrial output is to rise from its present meagre 7 % to 25 % in the year 2000. The realization of this aim has to allow for the close interrelationships between industrialization and other necessities in the countries concerned, e. g. in the field of income growth, employment, food and health, participation in regional and international trade, balance between rural and urban settlements, infrastructure, education and skill formation, science and technology, research and development.¹ Besides, the industrialization process in a particular country must be adjusted to its resource endowment and has to take into account a large variety of other considerations of social, financial or political nature.²

Determinants of Development Technology

In this context "development technology" plays a crucial role. This term is used to denote a type of technology which is particularly well suited to further general socio-economic development, taking into account the entire set of conditions prevailing in the country where it is employed.

Among the factors, which — apart from the above-mentioned general necessities — determine technology in a developing country, climatic influences

such as wind, temperature, humidity, solar radiation, besides biological effects, range first. Secondly, available materials and forms of energy exert a considerable influence. Thus, bio-mass, solar and bio-energy play an important role in the absence of conventional forms of energy: the utilization of power alcohol as a fuel for internal combustion engines may serve as an example.³ Furthermore, production has to be adjusted to available machining capabilities, the design to prevailing standards; both must, of course, be related to sales possibilities.

Combined these factors influence technology and thus actual production: for instance, a small volume of sales, and consequently of production, tends to change technological processes in the direction of

¹ Cf. H. A. Havemann: Technik im Dienst der Entwicklung der Dritten Welt (Technology for the development of the Third World), in: Technische Mitteilungen, Organ des Hauses der Technik e.V., Essen, No. 2, 1976, pp. 53-63; F. Stewart: Technology and Underdevelopment, second edition, London 1978.

² Cf. H. A. Havemann: The Adaptation of Technology to the Situation in Developing Countries, Background Paper No. 3, Study Group on the Choice and Adaptation of Technology in Developing Countries, 7-9 November 1972, Organisation for Economic Co-operation and Development, Development Centre, E 56 428, 1972; by the same author: The Transfer of Technology — Some International Aspects, Paper prepared for the International Seminar on Technology Transfer, New Delhi, 11-13 December 1972, 1972.

³ Cf. H. A. Havemann et al.: The Utilization of Power Alcohol in Combination with Normal and Heavy Fuels in High Speed Diesel Engines, in: Journal of the Indian Institute of Science, Vol. XXXV, No. 4, 1953, pp. 215-247; by the same author: Studies for a New Hot Air Engine. Part I. A Principal Thermodynamic Analysis. Part II. A Further Thermodynamic Analysis, in: Journal of the Indian Institute of Science, Vol. XXXVII, No. 3, 1955, pp. 243-291; by the same author: Studies for a New Hot Air Engine. Part III. Fundamentals of Heat Exchanger Operation with Oscillating Flow, in: Journal of the Indian Institute of Science, Vol. XXXVIII, No. 3, 1956, pp. 172-202.

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substituting labour for capital. In combination with the availability of labour and of raw materials, research and development of new processes, tailored to the specific conditions and needs of individual developing countries, might well become decisive for industrialization. The direct reduction of iron ore, as practised in Mexico, can be taken as an example.

The following system of development technologies may contribute to clarify the many-sided implications of introducing appropriate technologies in, and transferring them to, the Third World. It is expected to help in establishing organizational and research facilities working in harmony with the actual conditions and requirements.⁴

Imported versus Traditional Technology

Technical products imported into a developing country from an industrialized area are determined by

⁴ Cf. H. A. Havemann, H. M. Rady: Technologiehilfe für die Dritte Welt: Die Evolution der Entwicklungstechnik, Systematik – Forschung – Beratung – Beispiele. (Technological aid to the Third World: The evolution of development technology. Systematisation – Research – Consultancy – Examples), Internationale Kooperation, Bd. 20, Baden-Baden 1979, pp. 157-177.

conditions in the latter and do not take into account the availability of materials, spare parts, energy, trained manpower, e. g. for regular servicing, in the former. Besides, they tend to require high initial investments in currencies which the developing country can earn only by exports. In many cases the level of production capacities of the imported plant surpasses the demand of the local or even regional market. Thus, the product is bound to be expensive which again tends to diminish sales. The usually high degree of automation precludes the intensified utilisation of available labour.

Quite contrary to imported technology the technology which has grown in the developing country itself is perfectly adjusted to its conditions, e. g. in the areas of rural applications, textiles, handicrafts, small workshops and, these days, in industrial estates. Labour is used intensively and cost structures, as well as the goods produced, meet the existing possibilities of the market. The scope may not reach very far, measured against a scale of product complexity but vast numbers of people, particularly in the rural areas, assure consumption. The most important form of traditional technology is devoted to food production

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V E R L A G W E L T A R C H I V G M B H - H A M B U R G

and simple irrigation systems. Handicrafts are often devoted to the manufacture of requirements of everyday life, such as footwear and clothing as well as simple requirements for housing. The means of production should as far as possible be such that they can be built in the rural areas by the workers themselves.

With imported and traditional technologies two ends of a scale are characterised, one denoting the perfectly adjusted, the other, the externally oriented type of technology. For the following three other types of technology – production, process and project technologies – the degree of adaptation has to be determined specifically in each individual case.

Production, Process and Project Technologies

The field of *production technology* is the industrial manufacture of technical products, mostly with the help of imported machine tools. The choice of product and production volume is determined by purchasing trends and power but additional considerations are to be given to sub-suppliers, readily available standardized materials and spare parts as well as to trained personnel and assured energy availability. Prices have to be determined in harmony with the conditions of internal and/or external markets, the latter assuming particular importance as they provide foreign exchange for purchases of industrial equipment from abroad. In the context of production technology infrastructural facilities for prompt and reliable transport of incoming and outgoing goods and materials are of prime importance.

In the case of *process technology* the role of production is replaced by technological standard processes such as steel making, the production of cement, the refining of hydrocarbons, etc. While principles of standard processes can hardly be changed, certain details may have to be adjusted to the circumstances in a developing country. First importance assumes the rate of production: imported

process equipment tends to produce at an extremely high rate in unit time so that actual consumption has to be assessed carefully. In this context minimizing production but still maintaining a reasonable price structure poses a serious problem. Other peculiarities can be traced to climatic conditions: due to high ambient temperatures air cooling, for instance, might not be acceptable⁵.

Up to now the different aspects of development technology have dealt mainly with micro-technological phenomena. *Project technology*, on the other hand, looks at the preconditions necessary for a whole project, may it be devoted to a process or to production. Here the discussion concerning the location of a plant would take place, its linkages through the necessary infrastructure such as for transport and communications, its provisions for personnel, such as housing, social services, recreational facilities, schooling and supply of everyday necessities as well as for health maintenance and protection. Thus, socio-cultural considerations are involved to safeguard the efficiency of work. On the other hand, the consequences of a project have to be assessed carefully. Some projects in Egypt, the Assuan dam or the Quattara project, may be quoted as examples demonstrating that considerably more attention should be given to project implications⁶.

Innovative Technology

Adjusting conventional imported technologies to the many-sided conditions in the Third World requires the solution of sometimes very complex problems. New measures have to be designed to achieve this adaptation. Even improvements of traditional technologies are possible. Besides, a certain degree of mechanization of agricultural implements has to take place: with progressing industrialization or modernization parts of the population will leave the rural labour force to take up employment in other areas. Consequently a larger number of people will have to grow and supply food for more consumers on essentially the same area under cultivation. This necessitates improved efficiency of production which can only be achieved by better tools. The high intensity of solar radiation suggests its utilization for air-conditioning and cooling of food supplies in storage. In hot coastal areas solar desalination of sea-water would be feasible. Tropical plants can be processed for bio-energy or for fuels for internal combustion engines, or else for bio-gas⁷. Even fertilizers can be derived in connection with advanced bio-mass utilization. Generally it can be said that technologies of

⁵ Cf. H. A. Havemann: Technologie-Transfer in Entwicklungsländer: Der Versuch einer Strukturierung, mit besonderer Berücksichtigung Lateinamerikas (Technology transfer to developing countries: a systematic approach with special regard to Latin America), in: Zeitschrift für Lateinamerika, No. 7, Vienna 1975, pp. 5-28.

⁶ Cf. H. A. Havemann, H. M. Rady, op. cit., pp. 267-327.

⁷ Cf. H. A. Havemann, H. M. Rady, op. cit., pp. 563-586; H. A. Havemann, H. M. Rady, R. Raubenbach: Pre-Feasibility-Studie zur Herstellung von Methan aus Bio-Masse in Ägypten: Verfahren zur biologischen Energiegewinnung (Pre-feasibility-study for the methane production from bio-mass in Egypt: Method for biological energy generation), Aachen 1976; H. M. Rady: Dangers and Utilization of the Waterhyacinths, in: Plant Research and Development, Vol. 10, 1979, pp. 46-52.

production, of processes, of projects, if applied in the Third World, can only meet the demands for and expectations of socio-economic growth, if they are suitably adjusted, by innovative steps, to conditions there.

Technology Transfer

One essential element of development technology, being largely non-technical, has not been mentioned: the transfer of technology. Most predominant is its role in connection with "imported technology", but even in the case of "traditional technology" a transfer from other developing countries can lead to important and quick advances. Again, a systematic approach is possible. The transfer of technological experience and know-how in any form of partnership, through investments, patents and licences can be described as being "horizontal": it can be achieved across the boundaries of countries or within a country itself. Another form of technology transfer, the "vertical transfer", embodies the progress and evolution of technological solutions to a given problem: from identification and an idea of its feasibility it passes through theoretical and experimental treatment to pilot plants and from there to the ultimate process or project of industrial realization and production.

The effort of a developing country, which wants to advance through industrialization, can only be successful, if it subscribes to the requirements of "development technology" in all its above-mentioned aspects. Through technology transfer available technologies become accessible and their utilization becomes possible. However, an organization must be established to ascertain that development technology is being activated⁸. For its establishment the above system of development technology can serve as an essential guideline if combined with major aspects of industrialization and of engineering research and development.

Organizational Suggestions

The organizational set-up of such an institution, located in a developing country and devoted to the realization of development technology, could be subdivided into fields which are defined in analogy with the latter's elements. There could be sections for: general industrialization; imported technology and technology transfer; production, process and project technologies; traditional technologies and rural mechanization; and lastly, innovative technology and engineering research and development. It is essential

that none of these sections works isolated from the others; on the contrary, a close integration is an absolute necessity.

This is most obvious in the case of the *industrialization section*, which would have to define general policies and absorptive capacities, assess requirements and necessities for technological action, collect information and statistics, and draw up the general financial framework for the industrialization process. Equally important are human, economic and social implications together with tasks of skill formation and technical training. General pre-requisites have to be cleared here, such as the supply of energy, water, transport facilities, materials for the industrial centres. It might be advisable to collect general information and documentation in this section. Furthermore, consultations for the public should be provided unless the subjects are of a specific nature so that they are better dealt with in the other, more specialized sections. A centralized question and answer service – national, regional, and international – should be established.

The *section for imported technologies and technology transfer* should provide information on available engineering equipment and on potential partners for joint ventures and for direct investment. Here, processes for technology transfer must be designed and advice given to interested parties abroad and in the developing country. The time and cost structure of such transfers should be discussed. A patent law might have to be evolved as time goes on. Licencing agreements should be negotiated. Technology due to be imported should be scrutinized with respect to consequences for the countries' existing technological structures. The vertical technology transfer poses another task for this section, which must closely cooperate with the section for technological innovation.

In the area of *production, process and project technologies* the most outstanding activity would be

⁸ Cf. D. Goldschmidt: Entwicklungshilfe ohne ausreichende Entwicklungsforschung? Vorschlag für ein Institut für internationale technologische Zusammenarbeit (Development assistance without adequate development research? A proposal for establishing an institute for international technological cooperation), in: J. Tinbergen (ed.): Der Dialog Nord-Süd. Informationen zur Entwicklungspolitik, Frankfurt am Main 1977, pp. 176-187; H. A. Havemann: Zentralinstitut für Entwicklungstechnik (ZET), Teilbericht zum Thema: Der mögliche Beitrag der BRD zum Transfer von Technologie in Entwicklungsländer. Forschungsbericht für das Bundesministerium für wirtschaftliche Zusammenarbeit (BMZ) (Central Institute for Development Technology, Partial report on the possible contribution of the FR Germany to the technology transfer to developing countries. Research study on behalf of the Federal Ministry for Economic Cooperation), Aachen 1973.

management and planning procedures, through which priorities must be set in harmony with the requirements and material resources of the country. Thus an element of adaptation assumes importance to a more decisive extent as might occur in the second section. Much attention would have to be placed on setting-up plants in the areas mentioned, in the proper sequence of testing, small and medium scale pilot plant operation up to the final establishment for actual operation⁹. Here the institute would have to offer intensive management and consulting activities combined with the evaluation of already existing and operating plants. Adjusting technology to demand and available financial resources falls within this area, too, as does the central problem of general technological adaptation and modification in the areas under consideration. The section for technological innovation should be called in for assistance frequently.

A guarded modernization of small scale industries and handicrafts should be the general aim of the *section for traditional technologies*¹⁰. Close contacts must be maintained with rural areas. Comparatively simple gadgets can ease manufacture. A closely organized net of consultative and extension services must be provided. New fields for the utilization of products of agro-industries should be sought. Increasing the productivity of labour in workshops and on the fields also falls within the purview of this section. An expansion of the production of foodstuff should still be pursued, though, strictly speaking, not belonging to this area. The establishment of an increasing number of industrial estates, with proper supervision of their operation, would serve the all-important aim of retaining the rural population in the country and creating jobs for additional income and purchasing power besides improving the capabilities of the workers. Their professional training as well as the training of supervisors would be the responsibility of this section of the institute for development technology.

The *section for technological innovation* would give priority to the scientific viewpoint. It should be equipped with a library and technological

documentation. Even more important would be testing equipment and machine tools to fabricate test rigs and prototype parts. Often, universities which dispose of appropriate facilities could be made aware of the needs of the local or regional industries; with these universities close contacts should be established. This section, again, should be ready to render consultative services and undertake contract research and development. However, it should also consider possibilities of the use of resources of the developing country for novel purposes such as the utilization of special plants for energy¹¹. Close contacts with the regional institutions and international organizations are advisable. The establishment of a far-reaching and detailed documentation on patents in related fields is a necessity. Most importantly, the general problem of substituting imports by gradually evolving original equipment must be pursued.

International Cooperation

Although the organizational proposal outlined here is meant primarily for a developing country it can also serve as a general guideline for an institution in an industrialized state. A somewhat similar structure would make it easier for the two institutions to cooperate. The sections of the institution for development technology in an advanced country could, indeed, work in close accordance with the principles and fields outlined for a developing country. As an example of such an institution, the "German Appropriate Technology Exchange" (GATE) can be mentioned. Other institutions, such as technical colleges and universities, could enter into partnerships with development technology institutes in the Third World. This approach recommends itself particularly for such fields of technology, in which developing countries offer advantageous conditions, e. g. for research concerning the utilisation of solar energy.

Scientific disciplines as well as research findings, which in most cases are adequately documented in different countries, should be combined into one overall conception by an institution as described in its basic outlay. Detailed plans can then be consolidated into a comprehensive strategy by interdisciplinary and international techno-economic cooperation.

⁹ Cf. H. A. Havemann: Some suggestions on the organization of an activity in the area of "Appropriate Technology", Aachen 1976; by the same author: Tropical Technology, in: Applied Sciences and Development, Vol. 1, Tübingen 1973, pp. 32-43.

¹⁰ Cf. H. A. Havemann: Bericht zur Konferenz über "Angepaßte Technologie" in Mexiko, 21.-26. Juni 1976 (Report on the conference on "Appropriate Technology" which was held in Mexico from June 21-26, 1976), Aachen 1976; by the same author: Zur Eröffnung des Aufbaustudiums "Technologie in den Tropen" (on the opening of the continuation study of "technology for the tropics"), in: Kölner Fachhochschulhefte, No. 3, Schwerpunkt-Heft Eröffnungsveranstaltung Aufbaustudium Technologie in den Tropen, 1976, pp. 21-28.

¹¹ Cf. J. A. Alich, Jr., R. E. Inman: Effective Utilization of Solar Energy to Produce Clean Fuel, Stanford Research Institute, Menlo Park, California 1974; Battelle Columbus Laboratories (ed.): Fuels from sugar crops, Conference Proceedings, October 13-15, 1976, sponsored by the Energy Research and Development Administration (ERDA), Columbus, Ohio, 1976; H. A. Havemann, H. M. Rady, op. cit., pp. 482-500; H. M. Rady: Der "blaue Teufel" – Segen oder Plage? (The "blue devil" – blessing or plague?), in: Umschau in Wissenschaft und Technik 77, No. 17, 1977, pp. 576-580.