PROJECT TWO

LEAD PAPER

TECHNICIAN EDUCATION AND TRAINING: A SHARED RESPONSIBILITY OF INDUSTRY AND TECHNICAL INSTITUTIONS

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Many scholarly reports have been written on Technical Education and Industry Co-operation. Many national, regional and international conferences have been held on this subject; and all of them have produced extensive recommendations on why and how to promote such co-operation. The education archives of all countries are replete with the reports. I would therefore not like to add to the available literature merely to repeat what has been said before.

After all is said and done, so much has been said, but so little done! Why is this problem still dogging us? What crucial factors have been overlooked and are therefore acting as a barrier between technical institutions and industry- What must be done to remove the barrier and how? Who should take the lead?

It is to these issues that I will address myself in this paper and develop the thesis that the concept of "co-operation" is a weak one and should be replaced by the strong concept of "shared responsibility" to demand of both technical institutions and industry a joint effort towards human resource development. I go further and argue for a state policy in all countries, which spells out the complementary roles of institutions and industry and how they should play their respective roles.

In all of this and more, I will confine myself to the education and training of technicians, although much of what I have to say will apply equally to technologists and skilled workers.

The reason for addressing myself specifically to technicians is that of all areas of technical education, the education and training of technicians is the most crucial, but most misunderstood. It is also the most mismanaged because of the conflicting attitudes and approaches between technical institutions and industry. My concept of shared responsibility is best applicable to this area.

At the outset, the term co-operation used as a label or slogan appears to reveal and explain. Actually, like other catchall phrases, it conceals and confuses. The term implies existence of conflicts, cross purposes and rivalry which can only be resolved by the parties concerned agreeing to work together in their common interest. It has also overtones of equality among the parties. None of these is true where technical institutions and industry are involved, particularly in developing countries. Each has grown into a separate system

propelled by its own internal dynamics and with no interaction with the other. Although the concern of one is to train and supply usable manpower and that of the other to get trained manpower, develop it and profitably utilise it, the gap is lack of acceptance of this common objective by both systems and joint responsibility to achieve the objective.

Historical Background

This is the crux of my argument. Historically, in developed countries industry started first with the application of technology to the production of goods and services needed by society. Industry recruited young persons with some general education, trained them on the job as apprentices, and employed them. As technology advanced, industry needed not merely workers with operative manual skills which they could apply on machines and other equipment; it needed the workers to be equipped with a wide range of scientific and technical knowledge with which they could cope with complex problems of design, production and construction. It is in response to this need that technical institutions came into being and started offering part-time, day release, block release courses to persons working in industry. Thus a whole system of apprenticeship and technical education developed with a close matching up of the roles of industry and technical institutions. As technology advanced on a broad front, a new stimulus was given to research and development which in turn added new dimensions to technical education over the years. In this process, the interdependence of technical institutions and industry was established.

In the so-called developing countries, industry and technical education took totally different courses in their development. Technical education came first as an integral part of the educational systems of the countries. Industry came next as a result of totally different forces. Most of those countries were for many long years colonies and the colonial rulers introduced what is known now as public education to provide the people with an access to western civilisation and culture on the one hand, and on the other, to induct the colonial people into administration. In course of time, education came to be identified with access to government employment, but since government employment was limited to clerical and other white-collar jobs, the colonial powers introduced vocational and technical courses into the educational systems so that boys and girls might acquire useful skills for gainful employment outside government sectors. Industrial activity was limited to the processing of raw materials for overseas markets, mainly with the help of expatriate capital, know-how and technical personnel. Entrepreneurs used local labour for unskilled or semi-skilled work.

All this may be history, but the point is that from the beginning there was hardly any connection between technical education and industry in developing countries, and each took its own course for manpower development. Although much has since changed in all those countries and both industry and technical education have made significant progress, the historical gap still persists. In essence, the gap is that industry does not have any stake in the educative processes of the manpower that it needs. It has been merely a consumer of the products of the educational system, has stood outside the system, at times as a critic and at other times as a disinterested spectator. The educational system has identified itself exclusively with social services and become more responsive to social demands than to industry's manpower needs. Hence the criticism of industry that technical institutions are not producing the correct types of engineers and technicians useful in design, construction, production and similar activities; and the counter-argument of institutions that industry expects too much of them to the exclusion of its own

responsibility. The vicious circle must be broken by bringing them together to understand each other and work together towards a common goal.

The process must start with determination of the common goals in precise terms and identification of the methods and means of reaching them. To examine these problems with reference to technicians and develop the thesis of shared responsibility:

Planning of Technician Education

Who is a Technician?

Definitions are difficult, because we do not know for certain whether to relate a technician to his educational qualification or to his functions in specific occupations. There is no unique relationship between education and occupation. The First Commonwealth Education Conference in 1959 gave the following definitions:

Technologist	:	a person holding a degree or equivalent professional qualification in science or engineering, who is responsible for the application of scientific knowledge and method to industry
Technician	:	a person qualified by specialist technical education and practical training to work under the general direction of a technologist
Craftsman	:	normally a person who has served a recognised apprenticeship and who applies his skills on the shop floor.

The Commonwealth Conference definitions of a technologist and technician are mainly in terms of their educational qualifications. But educational qualifications are vague indicators, because there are no universally accepted standards of education at any level. Also, in these definitions there is no indication of the level and content of the educational preparation of technologists and technicians and how they are related to their respective professional functions.

Another Commonwealth Conference on the Education and Training of Technicians held at Huddersfield in October 1966 came to the following conclusion:

> "The Conference quite deliberately rejected the temptation to attach a specific clear-cut meaning to the term 'technician' and accepted the impossibility of finding an acceptable definition which would cover the whole range of industry and commerce. It was recognised that, throughout the whole range of industry and commerce, there is a broad spectrum of occupations lying between the craftsman on the one hand and the professional (or technologist) on the other. Within this spectrum there are wide differences, both in subject interests and in degrees of expertise, which must be taken into account when planning educational and training programmes, but the whole band does represent a unique and distinguishable group of people who, whatever their specific functions, can be broadly classified as technicians."

Many other agencies, committees and commissions have also attempted definitions of a technician. Typical of such definitions is the one adopted by the Haslegrave Committee (1969) of the United Kingdom:

> "Technicians and other technical supporting staff occupy a position between that of the qualified scientist, engineer or technologist on the one hand, and the skilled foreman or craftsman or operative on the other. Their education and specialised skills enable them to exercise technical judgement. By this is meant an understanding, by reference to general principles, of the reasons for and the purposes of their work, rather than a reliance solely on established practices or accumulated skills."

Unfortunately, these and other definitions do not help us much to understand who a technician is and what his functions are. The definitions are too general, give merely an educational identity and locate a place for him in the manpower spectrum between a technologist and a skilled worker.

How does industry view a technician? Totally differently, because industry rarely uses this expression and identifies him with reference to a wide range of functions associated with an equally wide range of job titles. For instance, in industry's view, a technician is one who carries out one or more of the following functions:

> applying known technology to field operations in production and construction; testing and development; installing and running engineering plant; drafting and designing products; estimating cost; selling and advising customers on the use of engineering and scientific equipment; liaison between engineer and skilled worker to interpret plans and designs, determination of production and construction techniques; choosing tools and machines best suited to each job; supervising skilled workers; and assisting engineers in design offices, laboratories, etc.

It is evident that educationists' definition of technician and that of industry are not congruent. The former equates a technician with a mere academic course in an institution and the latter categorizes him according to his functions, but there is no matching up of the course with the expected functions. Hence, the oft repeated complaint of industry about the unsuitability of the products of technician institutions.

Therefore, the first area of shared responsibility of technician institutions and industry is to identify the technician, delineate his precise functions in industry, determine the knowledge, skills and competencies needed to perform the functions, and design courses of education and training which will best serve the purpose. This demands an activity analysis of technician occupations in industry:

> (a) To know where technicians work: the different departments of an industrial organization where technicians are employed, as for example:
>
> > Commerce: departments whose work is directed outwards to the supplier and customer.
> >
> > Research, Design and Development: departments engaged in technical work which leads up to the decision to produce on a commercial scale.

Production: departments whose work ranges from the point of decision to produce up to the stage of the finished product.

Services: departments whose work supports two or more of the above.

This survey gives us distribution of technicians by their functional classification and by their job titles. From this we will also know the main areas of work of technicians and the type of jobs done by them.

(b) To study what technicians do in their jobs i.e. the work content of their jobs in each functional area, which can be rationally grouped. As for instance:

- **Communications**
  - (1) Written Communications - reports, correspondence, etc.
  - (2) Written Communications - quotations, specifications, schedules, etc.
  - (3) Verbal Communications - liaison with customers, answering queries, etc.
  - (4) Drawing
- **Design**
  - (5) Design of components, circuits, tests, etc.
- **Organizing Work**
  - (6) Planning, Control, Programming
  - (7) Appraisal, Evaluation of Company Practices, etc.
  - (8) Purchasing, Stock Control, Materials Ordering
- **Diagnosis**
  - (9) Measuring, Testing, Inspecting, Work Study
  - (10) Fault Finding, Diagnosis
- **Practical Work**
  - (11) Servicing, Maintenance, Installation
  - (12) Assembling, Manufacturing Operations
- **Supervision of Other Staff**
  - (13) Supervision
  - (14) General Administration

(c) To prepare on the basis of (a) and (b) above on activity profile of technicians which will give a three-dimensional matrix of technicians by their functional classification activity composition and relative proportions of their activity categories.

Technician functions constitute a broad spectrum. At one end of the spectrum are near-professional functions which demand of the technician a sound broad-based knowledge of the chosen engineering field and the ability to apply that knowledge to the day-to-day practical problems of design, construction or production in industry. At the other end are technicians who are required to have a mastery of manual or manipulative skills of the craftsman type with the relevant knowledge of engineering to control and supervise production operations on the shop floor. In between are technicians who are required to have different proportions of professional engineering knowledge and practical skills, depending upon their precise functions in industry. Their education and training must therefore aim at equipping them for those functions. In the last analysis each technician course must have its own integrity.

Therefore, it is only when technical institutions and industry jointly carry out an activity analysis of technicians on the above lines, form clusters of technician occupations according to well-defined common characteristics, and determine for each cluster the type of technical professional knowledge, skills and competencies needed that a coherent system of technician education may be evolved. Only then will it also be possible for technical institutions to define correctly the objectives of their technician courses to guide all the other components of the system, especially the curriculum and its design. The technician curriculum thus designed should equip a technician to the following:

(a) Apply basic principles, concepts, and laws of science relevant to his field of speciality.

(b) Apply mathematics as a tool in the development, definition or quantification of scientific development according to the requirements of his speciality.

(c) Perform specialized services required in relation to materials, processes, equipment, procedures, methods and techniques.

(d) Investigate technical problems using scientific method of inquiry and observation.

(e) Establish an effective rapport with other professional and non-professional workers within his field of speciality.

(f) Transmit and receive facts, ideas and data objectively through oral, graphic and written communication.

Technician courses thus planned must, however, have a broad educational character and not merely be to serve the immediate or here-and-now purpose of technician functions. We must remember that we are educating a technician for a minimum of thirty-year professional life. During that period, technology will advance, the nature of technician functions may change, and a technician may be required to adjust and adapt himself to wholly new circumstances. The technician whom we train today must therefore be equipped intellectually to cope with a future that we can only dimly visualize. He must be capable of transferring his knowledge from known to unknown situations with confidence. All this and more implies that technician curriculum must have a futuristic approach too.

Technician Curriculum Implementation

The next phase of shared responsibility of technical institutions and industry is in the implementation of the technician curriculum. This is a logical sequel to activity analysis and curriculum design processes discussed earlier.

A coherent system of technician education is a process which must take place partly in a technical institution and partly in industry. The business of a technical institution is to give the prospective technician a sound broad-based knowledge in the theory of his chosen field. With this he should be able to understand the basic principles of design, construction and production. He should be able to communicate his ideas to the expert and to the skilled worker. The curriculum must develop knowledge and mould attitudes to the highest level of proficiency. This education has to be cross-fertilized with practical experience in industry so that the technician-trainee is familar with working methods and skills relevant to his own field. He has to be made to observe and understand how engineering principles are translated into processes. He has to be as expert on the job in industry as he is expert in the underlying scientific knowledge that has to be applied in the job.

To co-ordinate theory with practice, to relate technical knowledge with work in industry, and to elaborate the complementary functions of technical institutions and industry - all this is the heart of the problem of technician education.

It is therefore no longer a question of just any kind of training or practical experience in industry, but of a joint effort by industry and technical institutions to design and provide that kind of practical experience which is relevant to a technician curriculum and promotes the initial growth of a prospective technician in real life situations. The basis for designing practical training should therefore be the technician activity analysis which has been carried out in consultation with industry.

The technician curricula designed on the basis of activity analysis will reflect the types of technicians needed by a country, depending upon the nature of industrial activity in that country, pattern of employment of technicians and technology level. Therefore, the nature and scope of practical training will vary according to each technician curriculum, but the following principles must guide each programme:

Induction: to acquaint a student with industrial environment and give him an understanding of the structure of industry, including the role of a technician. He must be made aware of the importance of industrial training to his professional development.

Training in Basic Skills: following preparatory training in the workshops of technical institutions or in industry, the student must be equipped with the knowledge and skills in various production operations and processes employed on the shop floor or construction techniques in the field. He should also get adequate experience of the techniques employed in the shaping of materials towards the final product. This involves an understanding of materials and their properties, production functions, time, cost, and method.

Engineering Practice: this part of the training should be in the field of speciality of the student, with particular reference to the main functions of a technician in that field. It should cover design-drafting, estimating and costing,

production/construction techniques including choice of tools and machines for a job, testing, installing and running of engineering plant, and supervision.

During this phase of training, the student should get acquainted with the working of the organization as a whole, including sources of capital and raw materials, production, sales, installation and servicing of the finished product etc. Finally, depending upon the time available and towards the end of the training, it would be a good thing to assign to each student or a group of students a project centred round the functions of a technician. The problem for the project must be suggested by industry from live situations and must demand of students' application of their knowledge and experience concerning design, drafting or production or construction or installation of plant, and testing.

The relevance of the training programme to technician curriculum must be further established by laying down:

(a) Training Specifications in behavioural terms: i.e. what types of knowledge, skills and competencies are aimed to be acquired by a trainee.

(b) Training Methods: i.e. with whom or under whose guidance a trainee will work, what procedures he will follow, what records of work he will keep etc.

(c) Training Examples: which will explain the actual jobs or work which a trainee will carry out.

All this and more implies that for each group of industry a training board consisting of representatives of industry, technical institutions and training officers should be set up to design the training programmes and oversee their implementation. The programme should have a built-in system of evaluation of training on the basis of which both technical institutions and industry may evaluate the total curriculum in actual operation and make the necessary improvements on a continuing basis.

Apprenticeship and Sandwich Courses

A variety of methods is practicable for the education and training of technicians in an integrated manner between technical institutions and industry. The most effective of the methods are:

(a) Apprenticeship in industry along with block or day release courses in technical institutions.

(b) Sandwich courses or co-operative courses.

Apprenticeship is one of the oldest social institution and although over the centuries it has undergone many fundamental changes, it has remained the main source of skilled manpower for industry. In almost all industrially advanced countries, a national framework has been evolved for the organization and administration of apprenticeship. Within the national framework, legislative provisions or administrative instructions regulate training in apprenticeship by laying down detailed job descriptions, training programmes and examination standards for each trade. These regulations too are being revised and elaborated on a continuing basis to ensure improvement in skill competency in the light of changing technological needs. In addition, in most countries, the central training authorities concerned also provide to industry

detailed training manuals, audio-visual aids and other training materials which are developed through extensive pedagogical research.

Apprenticeship is not confined to the training of skilled workers either in concept or in practice. The system is extended to the training of all other manpower formations in industry. Thus, the system includes, in addition to craftsmen, apprentices, student apprentices, technician apprentices, graduate apprentices and management apprentices. In Britain, under the Industrial Training Act, 1964, the Engineering Industry Training Board has on the basis of technician job analysis prepared model training programmes for technician apprentices. The training programmes consist of:

> Basic Training: Off-the-job training to prepare potential technician apprentices, particularly for the planning and diagnostic skills.
>
> General Training: to develop the abilities required by technicians and to impart the background knowledge and understanding of industrial practice essential to their first posts of responsibility and to their subsequent career development. The training includes Design Appreciation, Manufacturing Practice and Communication.
>
> Objective Training: to develop expertise in a particular technician function on the basis of identification of skill and knowledge requirements either of a specific job or of a family of related jobs.

All technician apprentices also start off on a complementary further education course on block release or day release basis, first to a Technician Certificate and later to Higher Technician Certificate or Diploma, depending upon their areas of specialisation.

Unfortunately, in most developing countries there is no organized system of apprenticeship to secure an adequate quantity and quality of training within industry. This is the cardinal weakness responsible for inadequate development of technical education and training in those countries. It is evident therefore that unless as a matter of state policy apprenticeship is made an integral part of manpower planning and development and industry enjoined to discharge this responsibility for its own survival, no worthwhile progress is possible. Appropriate legislation along with the setting up of industrial training boards, one for each group of industry, which must function in close co-ordination with technical institutions, is urgently needed.

The alternative route to technician education and training is Sandwich Courses which designedly integrate classroom learning with actual work experience in industry or in the professional field into a single educational process. The integrated process establishes for a student the meaningfulness of what he studies in his institution through appropriate experiences while on the job. It goes further: it develops a student's ability to increase his range of ideas in response to a much wider variety of questions and settings.

As a Joint Working Party of the Committee of Vice-Chancellors and Principals, the Committee of Directors of Polytechnics, the Association of Colleges of Further and Higher Education and the Confederation of British Industry has noted on the basis of actual experience of sandwich courses in Britain:

"The main virtue of the sandwich course is that it not only trains students at an early stage in professional skills and responsibilitieis by giving them the opportunity of relating their academic work to practical situations, but it also enables them to work in a mixed age group, in a multi-disciplinary environment and under different pressures from those encountered in educational institutions. It provides the opportunity to develop an understanding of human relationships at work, together with the appreciation of the social, economic and administrative considerations which influence industrial and commercial activities .... One of the most important indirect benefits of the sandwich course system is that it creates a bridge between education and the working environment. The links established for this purpose between educational institutions and industry and commerce often benefit each partner in the exercise by helping to achieve a better understanding of each other's objectives and role in society."

It must be emphasized that sandwich courses do not mean just working in industry. Nor is it intended to train an engineer or technician for a specific job in a particular organization. Sandwich courses are integrated education, with the college and industry providing the means in an industrial situation.

It is axiomatic that the success of sandwich courses depends upon close and meaningful partnership between technical institutions and industry. Both must share the same objectives of sandwich courses and agree to implement the programme as partners in the same enterprise, each complementing the role of the other. This demands interaction between the faculty of technical institutions and experts in industry on a continuing basis.

In structuring sandwich courses, co-ordination between theory and practice is of supreme importance, but it can be achieved only step by step through the joint efforts of academic and industrial experts. The former must agree that good education is not mere learning, but that it is knowledge applied to work. Practical experience in live situations leads a student to the same educational goals as classroom instruction. The faculty of institutions conducting sandwich courses must therefore accept practical work in industry as an important part of the learning process. It must be substituted partly for classroom work in which theory and practice need to be taught as an integrated whole, to demonstrate engineering analysis and synthesis. Likewise, experts in industry must agree to the essentially educational goals of sandwich courses which are reached only when a student is equipped with the knowledge and skills needed not merely for the here-and-now productive work in an organization, but to meet the challenges of new and unfamiliar situations yet to come.

Many patterns of sandwich courses are possible. "Thick sandwiches" require a student to spend a long period in industry between periods of college work. A typical example in Britain is the 2-1-1 system, in which industrial experience occupies a third year between two academic segments. In other patterns called the "Thin sandwich" shorter periods of industrial work alternative with periods of college study. For example, in a four-year course a student alternatively spends six months in college and six months in industry. There is also to be found the system of alternative weeks for college study and for industrial work. There is therefore no ideal pattern for sandwich courses. Each institution must devise its own way of integrating academic studies with practical training in consultation with its counterpart industry.

The importance of industrial training must be reflected in the efforts made to assess the performance of students during industrial periods. Written reports by tutors and industrial firms are one method of assessment. Other methods like oral examinations and continuous assessment must be tried, on the one hand to ensure fulfilment of the educational objectives of sandwich courses and, on the other, to have some measure of a student's attainment in his industrial work. All this assessment must also provide a means of feedback to improve the training programme and to define course objectives in operational terms.

Sandwich courses can be either institution-based or industry-based, depending upon who selects students. In the former, technical institutions select students and place them in industry for training; in the latter, industry selects and sends them to institutions for studies, in addition to providing the necessary training. In both cases, the whole programme of training and studies is jointly developed by industry and technical institutions.

Because of their integrated nature sandwich courses are longer in duration than conventional courses, but the advantages far outweight any objections to duration. It is, however, important that sandwich course students should be paid stipends at least for periods when they work in industry. For instance, in India, when sandwich courses were introduced some years ago, an incentive was built into the system in the form of stipends during industrial training and the entire expenditure on the stipends was borne by the Government. Later, the Indian Apprentice Act 1962 was designedly amended to legitimize industry's responsibility for sandwich courses. Industry is now required to bear fifty per cent of the cost of stipends, in addition to bearing the entire cost of training.

As an example of how conventional technician courses could be reorganized into more useful sandwich courses, a sandwich course jointly developed and implemented by an Indian polytechnic and industry is given at the end of the paper. In this example, the conventional course is three years long and wholly institution-based for the diploma in mechanical engineering. The reorganized sandwich course is three and a half years long and includes one full year of practical work in industry which is provided in three instalments: the first of three months sandwiched between two academic sessions of the second year; the second of another three months during the long summer vacation; and the last phase of six months sandwiched between the last two academic sessions of the course. The nature and scope of practical training in industry is also given in the example.

Conclusion

In this paper I have taken the stand that technician education and training as a means of human resource development of a country is a shared responsibility of technical institutions and industry. Both technical institutions and industry must discharge the responsibility in unison, first by identifying who a technician is, where he works and what he does; next, by determining from activity analysis what types of knowledge-skills mixes are needed for different clusters of technician occupations and developing appropriate curricular offerings; and finally, by implementing the curricula in close co-ordination either in the form of apprenticeship with complementary block release or day release courses or in the form of sandwich courses. To co-ordinate theory with practice, to relate technical knowledge with work in industry and to elaborate the complementary functions of technical institutions and industry - all this is the heart of the problem of technician education.

The problem of educating the engineer is similar and I would argue for the same concept of shared responsibility between engineering colleges and industry and methodological approaches to designing and implementing engineering curricula. Here, cross-fertilization between engineering colleges and industry must extend to research and design-development areas too to equip prospective engineers with higher-level ability and creativity on the one hand, and on the other, to push up the technology level of the economy of a country.

My point is that the education and training of engineers and technicians is a total effort in which the responsibility of technical institutions and industry must be clearly identified, delineated and directed within a national system.

Sandwich Course: Content of Practical Work in Industry

MCM Polytechnic, Avadi, Madra, is conducting diploma courses in mechanical and electrical engineering on the sandwich pattern. The courses are three and a half years long and include twelve months of practical training in industry. The programme of training is divided into three phases: three months, three months and six months. The first phase is sandwiched between two academic sessions of the second year course and the next phase is again sandwiched between the last two academic sessions. The broad outlines of the training programme are as shown below:

Mechanical Engineering

(Elective: Automobile Engineering)

First Phase:	Introduction: Nature of work done in different shops. Job Specifications for the trainees - what the trainees are expected to do. Understanding shop drawings. Study of different machining processes in different sections of the factory as specified, preferably on lathes, drilling, milling and shaping machines and also on turret and capstan lathes.
Second Phase:	Tool room work. Machine tool maintenance. Working on automatic lathes and general purpose machines. Drawing office work. Production-planning work.
Third Phase:	Planning work. Production processes. Plant layout. Materials control. Costing techniques; work study. Analysis of existing designs of components manufactured. Preparation of standard drawings for components supplied. Testing components using various gauges and instruments. Servicing of materials handling equipment. Servicing and maintenance of industrial engines.

Electrical Engineering

(Elective: Electrical Machines)

First Phase:	Introduction to the nature of electrical work in different sections of the factory. Work specification for the trainees: What work is expected of the trainees. Practice in fitting, welding, drilling, grinding, turning and other lathe work.
Second Phase:	Studying drawings of electrical layout and distribution systems in the factory. Maintenance and overhauling of electrical equipment in various shops, e.g. motors used for rolling mills, furnaces, cranes etc. Maintenance of batteries.
Third Phase:	Work planning. Layout of electrical plants. Materials control. Costing techniques: work study. Overhauling and servicing of electrical equipment. Materials handling equipment and control systems. Electrical plants in the factory including equipment in sub-stations.