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"The Role of engineering and consultancy services in the technology unpackaging of electric power projects in developing countries"

by

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Content:

0. INTRODUCTION

Various strategies have been considered in previous meetings and discussions at UNIDO to promote the development of the electric power sector in different developing countries. It has been concluded that the most promising strategy is to "unbundle" the technology package of such projects.

This is certainly true. Yet before going into this process of unbundling in some more detail, it may be helpful to have a short look at the complete picture.

Any electric power project is a functional link in a chain which leads from the primary energy to the final consumer. This overall task of producing and distributing electric power has always to be seen in total, also when considering a separate link in the chain.

PRIMARY ENERGY SUPPLY & PROCESSING	ELECTRICITY GENERATION	HIGH/LOW VOLTAGE TRANSMISSION	SUB-STATIONS, DISTRIBUTION	CONSUMER INSTALLATION { DOMESTIC, INDUSTRY, RURAL

Fig. 1: The "functional chain" of electric power projects

Know-how and experiences gained in one sector can and have to be transferred to the others. Building up local capacities for engineering as well as supply has to refer to the entire electric power sector, not just to one project. It seems for this reason appropriate to approach the problem in a general way which applies more or less to all types of projects.

It is, on the other hand, obvious that the different project types offer a different share to which indigenous suppliers can contribute. This share, generally speaking, increases from left to right, from generation to consumer installation which is in many countries handled to 100 % by local staff. Therefore some specific consideration will be given to the various project types.

Finally the organizational structure of cooperation between customer, international consultant and local consultant shall be discussed.

1. GENERAL CONSIDERATIONS ON CONSULTANCY SERVICES

Any electric power project is a rather complex system. It consists of a number of subsystems and components each of which implies various construction activities and needs a different degree of skill and experience to be performed. "Technology unpackaging" means basically to break down the system into its different components. This can be done in different ways and to a different degree; yet it is at first sight always a subdivision on a merely technical level.

There is however, besides this unpackaging under technical aspects, another dimension of unpackaging which we may call the time dimension. This time sequence of the various activities which have to be performed during a project is shown in Fig. 2. In the following considerations, we will focus our attention in the first place on the various steps along this time axis.

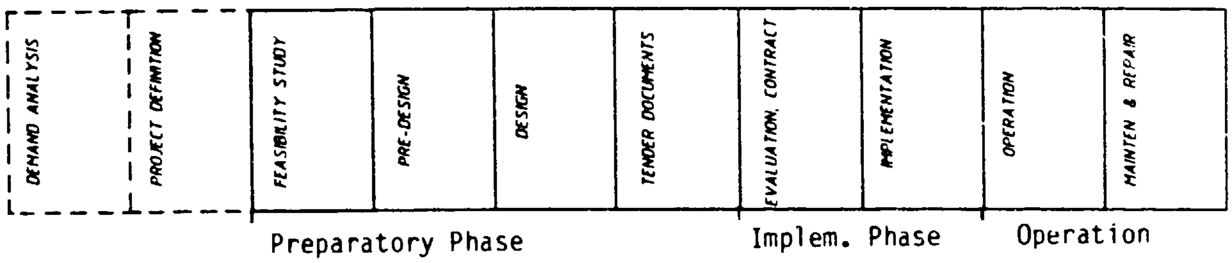

Fig. 2: Time sequence of activities for a power project

1.1. Preparatory phase

Very early in the preparatory phase it is highly advisable to select and entrust a well-experienced consulting engineer with the various tasks to be performed. There are some reasons to do so:

- First: It is not wise to make the same mistakes repeatedly at different places. This does not mean that a consultant is free of mistakes. But it means that, if ever possible, one should learn from what elsewhere has proven itself - or failed. A well experienced consultant who has performed projects in many countries is likely to bring in these experiences and help to avoid faults.

- Second: At the beginning of a project, design and cost can easily be influenced. The further the project progresses, the more difficult it becomes to exert this influence - in other words to correct decisions that turn out to be wrong. Therefore experience, know-how and long-sightedness are needed at the beginning of a project; it is useless at the end - except, of course, for the next time. This may be illustrated by the following graph (Fig. 3).

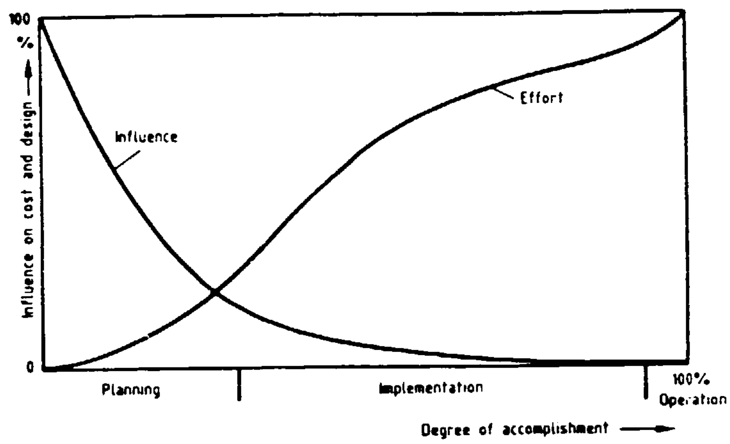

Fig. 3: Influence upon a project during various phases of realization

- Third: Preparing and carrying out a project means a peak load of work which can hardly be performed by any customer without additional staff - not even in highly industrialized countries. One should not try to build up this staff and release it again after the project has been completed. It seems better to build up, in due course of the project, local know-how and experience which can be kept and used afterwards. It should however be formalized in the engineering contract that help in building up local engineering capacity is part of the consultant's duties.

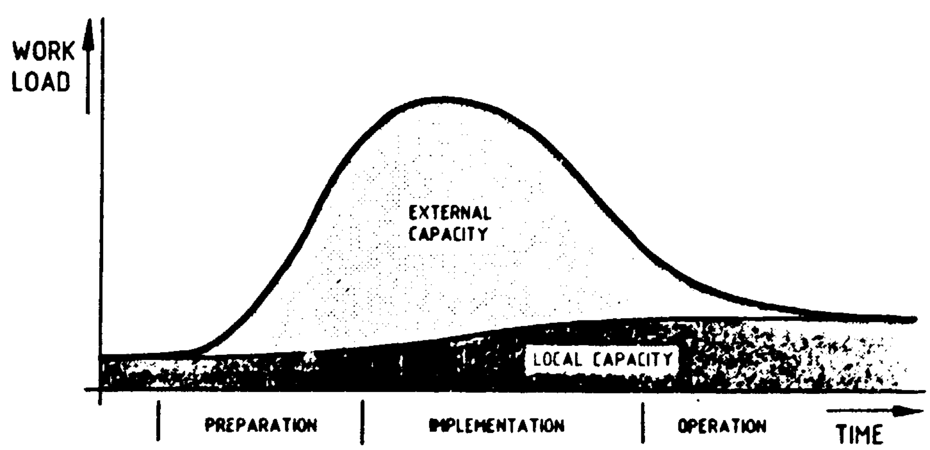

Fig. 4: Work load to prepare and implement a power project.

- Finally: The decision whether the work shall be contracted on a turnkey basis or split up into various lots must at least be left open at this early stage. There may be cases when a turnkey contract has advantages, but very often splitting into various lots is much better. In these cases the services of a consultant are indispensible; but also where a turnkey contract is envisaged a consultant can substantially improve the success of the project. We will come back to this subject later on.

With particular respect to the purpose of building up and involving local capacity into the project, to split up the work into some separate contracts is certainly of advantage. It means basically:

The more project lots, the more detailed the description of equipment must be. This, in turn, makes it easier for the potential suppliers to submit an offer. Therefore competition is open to far more suppliers, particularly also for local suppliers; their chances are improved.

Further advantages of breaking the total work into various lots are:

- Lower cost by broader market access
- Better cost control
- Increased influence upon technical standards of equipment
- Specific adaptation of design to capabilities of local suppliers.

In addition there are two most important advantages:

- The influence of the customer and his consultant is constantly maintained during the phases of detail engineering, contractual negotiations and implementation.

- The possibility of transferring technical know-how is increased. It is quite normal that a turnkey contractor has no interest in such a transfer. In this case it is one of the most important tasks of the consultant who handles the project to ensure this transfer to the greatest possible degree.

Of course the number of contracts cannot grow to an unlimited extent.

If it were to be done to the theoretically possible, utmost degree, for a steam power plant, to give an example, as many as 200 or more separate lots could be defined. This is of course not feasible.

The disadvantages of breaking into too great a number of different lots are obviously:

- Increasing difficulties to define and control interfaces
- Exponentially growing detail work in preparing tender documents and contracts
- More effort for proper mutual adaptation of technical components as well as coordination of time schedule
- Increasing risks for overall performance, because responsiblity of individual supplier is limited to his part of the work.

This means:
Overall responsibility for time, cost and performance is to an increasing degree transferred to the consultant, whicn, in turn, increases his workload and causes additional cost.

The various influences may be shown schematically by the following graph.

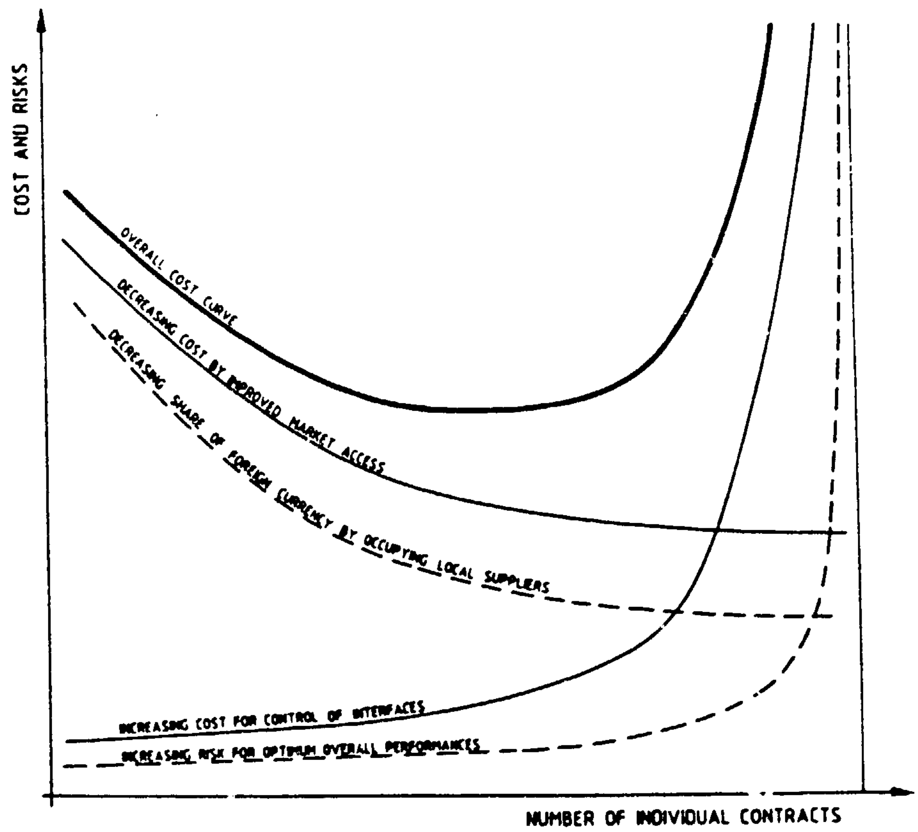

Fig. 5: Effects of increasing number of lots

An overall cost curve derived from evaluating the opposed influences may lead to an optimum which lies in our experience at about 15 different lots.

Some general criteria for this subdivision into several lots may be given as follows:

- Each lot must be accomplished by the potential supplier without difficulties
- Coordination efforts must be minimized
- Detail computations and disposition must remain within the responsibility of supplier as completely as possible
- The responsibilities must be covered by exact guarantee conditions
- Number of interfaces must be limited, responsibility for interfaces must be clear.

This breakup into various lots is aimed towards involving local suppliers as much as possible in the construction phase. Yet this breakup alone is not sufficient to achieve this purpose. The possibility to which degree indigenous capacities can contribute in the construction phase is pre-determined already at an early stage in the preparatory phase. If, in the feasibility study, various technical solutions are evaluated, not only the "least cost/best performance"-point of view has to be seen. Even higher cost may be the better decision if local firms can be employed and, at the same time, the share of foreign currency can be reduced. The options " steel girder" or "ferro-concrete construction" in civil works give an example. This continues in the design phase, and here it has, in fact, a particular importance which has a double aspect:

1: Design can be to some degree adapted to capabilities of local firms
2: Local consultants can in this stage be involved in the project and may help to optimize this adaptation process, increasing, at the same time, by their participation in itself the share of indigenous contribution.

The assistance of a local engineer in this process has the effect of a "connecting link" between the requirements of the project and the ressources and capabilities available in the country itself.

Actually during the pre-design and design phase a continuous feedback has to take place between design decisions and the capabilities of potential local suppliers.

There may be, for instance, chosen as material for switchgear tables concrete or steel plates as alternatives, the latter to be imported, the former to be supplied by local firms. Even if steel plates are cheaper it still is a better cost optimization to select concrete plates.

An established cooperation, not just casual discussions, with a local engineer - consultant or staff member of the customer - means some kind of "local market survey" and, at the same time, a pre-selection process of potential suppliers with respect to project requirements.

Because: Finding and encouraging local bidders is only one side of the coin.
The other is: To accomplish the project at reasonable cost in a reasonable time with the required performance data.

The mere judgement of the capabilities of local suppliers by a local consultant or even by local authorities or the customer himself may sometimes be too optimistic. It is therefore of vital importance for the success of a project to propose and agree with the client and, if necessary, with governmental authorities on a suitable prequalification procedure, which ensures that only companies with sufficient qualification are invited to bid for the project. This applies, of course, to international and local bidders in exactly the same way.

The procedure thus established should be agreed upon at the very beginning of the activities and on no account should it be changed due to influences which may be exerted on any party involved in the decision. It is the consultants' obligation to convince the parties concerned that to maintain the procedure once established is to the benefit of the project.

The more lots and, consequently, the more potential bidders, the more attention has to be paid to the preparation of tender documents. Increasing responsiblity of the consultant not only for the design of the project and its proper performance but also for management of construction work, time schedule and cost must be balanced by a high degree of care and accuracy in formulating these documents.

Basic guidelines for this important part of the work may be given as follows:

- Specifications should be detailed to such an extent that, on the one hand, competition is not limited, and on the other hand, it is not possible for the contractor to furnish goods and services below the defined standard.

- The scope of supply and services has to be specified as completely as possible, in order to avoid variation orders, the limits have to be fixed without any possiblity of misunderstandings.

- The specifications should contain not only a detailed description of the equipment itself but also a description of the tasks to be performed by the equipment.

- The potential contractor has to be informed that he must be aware of all local conditions which may influence the contract prices and that claims on such grounds will not be accepted. This may, in some cases, be of advantage for an indigenous bidder.

- A well balanced cost escalation formula has to be included in the documents.

- It is furthermore essential to inform the tenderer in the specification about the procedures to be used for evaluating his proposal.

Two things become quite obvious at this point:

- The consultant in its true sense as trustee and executor of the customer has a central function and responsibility for the success of the project. This has to be kept in mind when considering, later on, the framework of cooperation between customer, international and local consultant

- A local consultant or engineer, going through all this procedure together with an experienced international consultant, gets an excellent "on the job training". This cooperational training may be extended to bid evaluation and contract negotiations, enabling him to perform, in due time, similar activities by himself.

It must be seen, on the other hand, that for an international consulting office with world-wide experience and with well trained staff members, exerting this kind of cooperation could lead to a less efficient work performance than would be possible with an established team. Additional cost which arise for this reason should be seen as training and education cost; it will still be the cheapest way to transfer technical experience.

In this context it must be emphasized that the result when implementing a project in a developing country is, or at least has to be, not only the project in its physical sense. It is at the same time the technical experience which has been accumulated in the country during the time the project was carried out.

It is not the cost of the project alone that has to be minimized. It is the cost of the "combined products", the project <u>and</u> the technical know-how that has to be minimized.

A learning curve has to be established during the various phases of a project; and not only during one project but during all the projects that will be carried out in a country. We should remember, in this context, the chain of functional links shown at the beginning. Each link at every place of the functional chain must contribute, besides implementing a project, its proper share to the learning process that has to take place. We may illustrate this again by a graph.

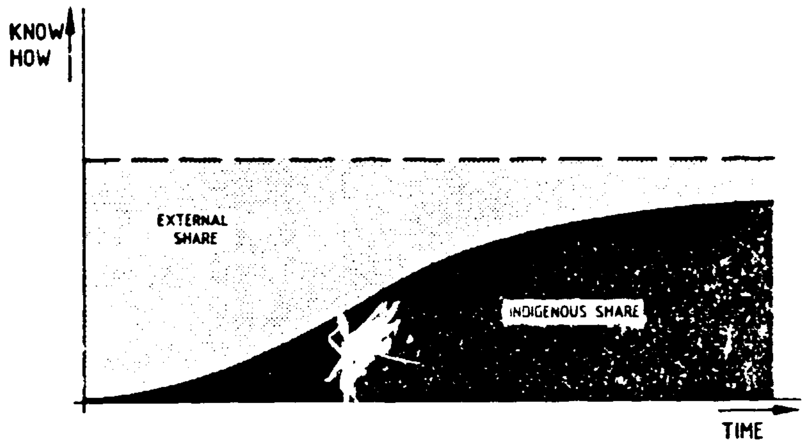

Fig. 6: Learning curve by implementing power projects

The more this learning effect progresses, the higher is the share of engineering as well as supplying work that can be performed by indigenous resources. It has, however, to be emphasized, that this process implies obligations and duties on both sides. Transferring experience and know-how of whatever kind needs always two parties; for one alone it is meaningless.

1.2. Implementation phase

In this phase there are two types of activities

- activities on site
- activities in the different factories of the suppliers.

Although the efforts of UNIDO are directed at promoting the manufacturing of capital goods in developing countries as well - or even in the first place - the aspect of manufacturing shall not be considered in this particular paper. The reasons are:

- Equipment of high technological standards is so far hardly manufactured in developing countries, as has been shown by UNIDO's case studies.

- The production of low technology cannot be established to supply only one defined project as it is the case, e. g. with consultancy services. Such production needs a market of some size. So all that can be done with respect to a single project is not to prevent the access of indigenously manufactured equipment if it is available at all.

One has however to keep in mind that manufactured equipment in the literal sense, i.e. made in some factory and shipped to the site, represents only a fraction of the project value, the remaining work share leaving considerable room for indigenous activities.

These remaining activities are

- Civil works of various kinds
- Supply and construction of ancillary facilities
- Installation of low and medium technology equipment (i.e. low pressure piping, electrical installations)
- Assistance in assembling high technology equipment.

The fraction to which these activities can be performed by local firms depends not only on the type of project but also on the state of development of the country. Some information on this subject will be given in chapter 2.

Task and responsibility of the consultant is shifted during the construction phase mainly to quality control, technical coordination and timing of the various activities.

Cooperation with and assistance of a local engineer again can be very helpful in this phase: He may help to transfer the quality standards necessary to the success of the project to the proper understanding of local suppliers and their staff who otherwise may be inclined to disregard sometimes the importance of quality requirements and the rigidity with which they have to be fulfilled.

This understanding for the necessity of defined quality standards is again part of "on the job training" for both parties, the local consultant as well as the local supplier.

As explained previously, the degree to which indigenuous capacity can be involved later on is determined to a large degree by the steps taken in the preliminary phase. In a similar way, local activities during the construction phase can again help to promote and accelerate local activities in the following phases: Operation, maintenance and repair.

Local firms and consequently local personnel occupied during the construction phase form the "nucleus" of a maintenance and repair crew which has to be established later in the operation phase.

This process can be encouraged by the consultant and his local colleague by

- defining the requirements and standards that have to be fulfilled by an appropriate maintenance staff
- assisting in pre-selection of future operating and maintenance personnel
- securing access of those staff members to activities which are of vital interest with respect to their future employment. This may even involve delegating future leading personnel of the maintenance staff for some time to the supplier's factory.

It may be repeated in this context, that such a procedure has as a prerequisite the continuously maintained influence of the customer and his consultant through all the project phases, which may be quite difficult on the basis of a turnkey contract. As has been mentioned previously here lies one of the main advantages of breaking the work down into several lots.

1.3. Operation, maintenance and repair

In this phase the function of the consultant is reduced to the role of a teacher and trainer. "Reduced" means by no account, that this function is of minor importance. On the contrary: In the process of technology transfer this may be even one of the most important steps helping to transmit technical knowledge, experience and familiarity even with highly complex technologies to an increasing number of individuals on various levels of activity.

Again the involvement of a local engineer is helpful in this stage: He will serve as an "interpreter" not only in the literal sense but also in the sense of bringing about a better understanding of technical processes and performance of equipment to the people dealing with them.

Of course this learning process does not end at a fixed date. While routine maintenenance will be carried out by local staff basically from the beginning of operation, more difficult work must be done by staff members of the manufacturer who perform continuously some kind of "advanced teaching" for a longer period of time.

What should end at a definite date is the involvement of the international consultant. His main objective in this phase should be to make himself unnecessary as early as possible.

The term "as early as possible" however cannot be defined generally. It depends on the complexity of the plant type as well as on the state of development of the country. In many cases the presence of the consultant's staff members lasts for several years.

Quite naturally this costs money. But this money pays off in three ways:

- by securing proper plant performance
- by avoiding faults which may be costly and reduce life expectancy of technical equipment
- by transferring an increasing amount of experience and knowledge

2. SPECIFIC REMARKS TO VARIOUS PROJECT TYPES

It has been mentioned previously that the degree to which indigenous suppliers can contribute depends of course on the type of project. The amount of work that can be performed by local companies is certainly different when dealing e. g. either with a steam power plant or a low voltage transmission line.

But the project type is not the only determining factor. There are other preconditions which strongly influence the possible indigenuous work share.

This is in the first place the state of development a country has reached. It makes a big difference if any industrialization of whatever kind has taken place so far, establishing some basic skill and workmanship in the population.

It is also important that the population is willing to accept industrial technology, to deal with it and become familiar with it. In this context it should be mentioned that this is a mutual approach: The more the indigenous participation increases, the more people are likely to identify themselves with the work. It is not a strange thing anymore that is going to be built here, but it is "our" power station. Here lies - besides economic purposes - an important reason to promote local participation.

Other factors are the geographical situation of the site within the country: Are there labourers at hand, or if not can they be mobilized and brought to the site? This, of course, implies the question if labour is available in the country at all which however is mostly the case.

One last yet very important point may be mentioned: Each population, wherever in the world, has its specific skills and knowledge. It is, in many cases, possible to make use of just these specific skills. To do so requires however some flexibility on the part of the planner. Again a team from an experienced international consultancy office together with a local colleague has the best chances to find ways and means to utilize such possibilities. An interesting example shall be given in chapter 2.2.

2.1. Power generation

It is well known that there exists a great variety of electric power generation plants. The following table may give a survey:

THERMAL POWER PLANTS	
with {conventional, renewable, nuclear} fuels	Steam Diesel Gas Turbine
HYDRO POWER PLANTS	
- run of river - reservoir - pumped storage	Large Mini Micro
SOLAR POWER PLANTS	Photovoltaic Thermal
OTHER POWER PLANTS	Wind Geothermal Others

Fig.7 : Basic types of Power Generation Plants

Obviously the structures of these various plant types differ considerably and, consequently, the possibilities of "unpackaging" and of involving local suppliers are different.

It is not possible to deal with all these plant types in detail. For illustration, a steam power plant and a diesel plant shall be selected, and some aspects of hydropower plants will be dicussed.

A steam power plant represents a highly complex system. The wide range of activities needed to implement such a plant can be listed as follows:

Civil works:	Soil investigations Preliminary measures Main construction activities - Hydraulic engineering structures - Technical structures - Non-technical structures - Infrastructure
Mechanical engineering:	Fuel supply Steam generator Flue gas treatment, disposal Steam turbine generator Steam/condensate system Cooling system Auxiliary systems
Electrical engineering:	Power engineering - Transformers - Switchgear Auxiliary plant
Control engineering:	Instrumentation and control systems Communication systems
Ancillary facilities:	Administration Workshops Stores Vehicle pool

Fig. 8: Main construction activities/subsystems of a steam power plant

When making an attempt to quantify the cost share of the various partial activities one has to keep in mind, that "Steam power plant" again stands for a great variety in size, in basic heat diagram, in fuel, cooling systems etc.. Moreover, local conditions on the site - such as ground, climate, existing infrastructure and many others - influence cost and their breakdown. So the figures which can be given represent a range rather than an exact number. They are drawn from experience with projects actually executed by FICHTNER Consulting Engineers, but they may vary from case to case and from country to country.

The numbers listed below in Fig. 9 refer to a medium-sized oil-fired steam power plant of 100 MW_{elnet} with live steam conditions of 175 bar 530 °C, single reheat and natural draft wet circuit cooling tower.

The table gives the cost share of the various sub-activities in % and an estimate of the range that can be contributed by local suppliers.

It has to be borne in mind that manufacturing is not considered in this paper; the share that possibly may be represented by locally manufactured parts - such as small motors and transformers, fans, ducts, etc. - is therefore neglected.

It is not surprising that the range varies so widely - from 8 to 28 % - considering all the additional influences that have been mentioned previously. Yet it may be called a satisfactory result that the contribution of indigenous firms can reach this comparatively high share even without involving any manufacturing. The breakup is made, in the table, in terms of cost. The share of labour is still somewhat higher considering the fact that labour cost is generally cheaper when employing local instead of imported labour - which applies basically not only to developing countries but in their case maybe to a larger extent.

Component/Activity	Cost share %			Cost share in % to be performed by local sppliers	
				favourable conditions	unfavourable conditions
Mechanical Part					
Fuel storage and supply		4		4	1
Steam generation		21			
Boiler			16		
HP-Piping			3		
Water treatment			0.5		
Ancillaries			1.5	1	-
Pre-heaters, pumps MP + LP-piping		5		2	-
Cooling system		2		1,5	-
Miscellaneous		4		3	-
Subtotal Mech. Part	36				
Electrical part					
Electricity generation		19			
Electric equipment		5.5			
High voltage			3.5		
Low voltage			1.5	0.5	
Light + power			0.5	0.5	
Control		7.5			
Miscellaneous		2		1	-
Subtotal Electric part	34				
Civil works					
Boiler house		5		2	)
Turbine house		7		3	) 2
Control room		2		1	)
Chimney		1.5		-	-
Cooling system		2		1	0.5
Non-technic. buildings (Admin., shops + stores, vehicle pool etc.)		4.5		4	2.5
Infrastructure		2		2	1,5
Subtotal Civil works	24				
Engineering	6			1,5	0,5
Total	100			28	8

Fig. 9: Cost structure of 100 MW_{el} steam power plant

As a second example a diesel power plant is chosen. It has 2 MW_{el}, the fuel is oil. Fig. 10 gives the breakdown into different components and the share that can be performed by local suppliers - again manufacturing not considered.

Component/Activity	Cost share %	Cost share in % to be performed by local suppliers: favourable conditions	unfavourable conditions
Fuel storage + supply	21	20	3
Engine + generator	42	-	-
Ancillary systems	5	3	1
Piping, ducts	3	2	1
Electr. equipment	6	2	-
Civil works:			
Techn. building	12	8*	2
Non-techn. buildings	3,5	3,5	2
Infrastructure	1,5	1,5	1
Engineering	6	2	1
Total	100	42	11

*) Considering vibration problems in foundation!

Fig. 10: Cost structure of a diesel power plant

The share of indigenous work is much higher in this case despite the fact that the diesel engine and generator set is assumed to be imported. In all cases it is advisable to buy engine and generator from one supplier only even if he does not produce both parts in his own factory. Serious difficulties with respect to responsibility and guarantee can be avoided should oscillating problems occur.

When considering hydro power plants as a last example, it is much more difficult to give the ratio of a possible local contribution in figures. The parameters which determine the cost of a hydro power plant are dependent to such a high degree on local conditions - such as topography, geological situation, hydrologic cycle etc. - that general numbers must necessarily cover a very wide range.

It can be said that mechanical and electrical equipment represents a smaller part of the total cost as in thermal plants, leaving 60 to 70 % of cost to civil works of various kinds.

The civil works connected with hydro power projects are to a large part fairly difficult, mentioning dams, galleries and tunnels as examples. They need special skills and experience to be built. Even considering that there is a large market for construction work in a developing country which gives an incentive to establish local capacities, they will, in most cases, not have the special equipment needed to perform hydraulic constructions.

On the other hand, not all the civil works are of such a difficult nature. Also in many cases a foreign construction company will send only a limited number of highly specialized formen and labourers together with the special equipment, and in addition engage a considerable amount of local labour under their responsibility. Of course this means not involving "local capacity" in the sense this paper is dealing with and UNIDO's efforts are aimed for. Yet also in such cases at least some of the money spent remains in the country, and some skill and experience can be transferred.

Due to all the circumstances mentioned it may be possible, in a fairly developed country, that the civil works for a small hydro power plant can under favourable conditions be performed by local construction companies to 90 % or even more, while for a large plant with difficult topographic conditions even in a well developed country an international specialist will be required leaving for local companies a share of merely 30 or 35 % of civil works, which represents around 20 - 25 % of total plant cost.

Again a consultant can help to maximize this share by breaking down the overall civil works into special hydraulic construction works and more or less "normal" civil works, dealing with both types in separate lots covered by separate tender documents.

2.2. Power transmission and distribution

In power transmission the possibilities of engaging local companies are, on average, higher than in the power generation sector. It depends - besides the influences mentioned at the beginning of the chapter - to some extent on the voltage level. This is not because it would require more skill and knowledge to erect a steel grid pylon for 110 kV than one for 30 kV, but in the former case the steel grid pylon is the only technical solution while in the case of medium voltage also other options may be considered.

This may be illustrated by the example of a 30 kV transmission line with a length of 60 km, planned and supervised by FICHTNER. Various technical solutions were investigagted in the preparatory phase each offering a different degree of local participation.

The solutions considered were wood poles, steel poles and steel lattice pylons. The following table gives again the cost share of the different components in each case and the degree of possible indigenous participation.

It is quite clear that the cost share contributed by local suppliers - or perhaps the staff of the customer himself - is higher when wood poles are used (which of course makes sense only if wood is available in the country. It goes without saying that a thorough impregnation is necessary.) Yet it may be surprising that the indigenous contribution in absolute terms is higher, despite the decreasing percentage, when steel lattice pylons are used. This is, of course, due to the higher absolute value of this solution and the higher cost share attributed to foundation and erection.

Components	Wood Poles Cost share %	Wood Poles Indigenous Contribution %	Steel Poles Cost share %	Steel Poles Indigenous Contribution %	Steel Lattice Pylons Cost share %	Steel Lattice Pylons Indigenous Contribution %
Poles/Pylons	13	13	25	-	29	-
Erection	11	7	24	12	19	9
Foundation	20	18	12	11	20	18
Earthing: material	7	-	3	-	2	-
labour	2	1,5	1	0,5	1	0,5
Isolators	9	-	4	-	3	-
Power cable: material	17	-	13	-	10	-
labour	4	2	3	1,5	3	1,0
Earthing cable: material	2	-	2	-	1	-
labour	1	0,5	1	0,5	0,5	0,5
Warning plates	2	2	1	1	0,5	0,5
Survey	3	1	2	0,5	2	0,5
Miscellaneous	3	2	3	2	3	2
Engineering	6	2	6	2	6	2
Total	100 %	49 %	100 %	31 %	100 %	34 %
Relation of absolute cost Expressed in "currency units"	100 C.U.	49 C.U.	135 C.U.	42 C.U.	170 C.U.	56 C.U.

Fig. 11: Cost structure of 30 kV transmission line

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It seems quite an interesting result that, expressed in absolute cost, the benefit for the indigenous economy is higher when selecting a high quality solution, even if this solution implies, in relative terms, a smaller local participation.

As a general conclusion it can be said that the evaluation and recommendation must be based, in the first place, on long term technical and economic advantages. There is no reason to reject an optimal solution only because the share of indigenous contribution is smaller. In other words: It is not helpful to recommend a solution merely for the purpose of increasing the percentage of local work share; the indigenous contribution for a project must be evaluated in absolute rather than in relative terms.

Also in the case given as example, the solution with steel lattice towers was finally selected.

There may be, however, even in the case of solutions with high quality technology, possibilities to make use of local skills and capabilities without any loss in quality. To give an example: For casting the concrete foundations of the steel lattice pylons, use is generally made of steel formwork which has to be imported.

However, during the course of one of FICHTNER's projects, it was discovered that the local population is very skilled in making wickerwork.

Thus baskets woven from bamboo or rattan are used as consumable formwork. This saves both costs and imports and considerably increases the contributions made by the local economy.

Naturally this procedure cannot be applied to all cases. However, with careful thought and by improvising to suit the particular case, it is often possible to find solutions of this type. The provision of derricks made locally in place of cranes specially brought to the site provides a further example. The local inhabitants often display an amazing degree of skill and expertise in the manufacture and provision of such aids.

Again a turnkey contract may be less favourable for finding and applying solutions of this kind. This is quite normal: The interest of a turnkey contractor must necessarily be directed towards delivering a good quality job in a reasonable time at low cost. In most cases, this means using standard methods and well proven, efficient equipment which must be utilized to the maximum degree to obtain a satisfactory return of the investment.

A brief survey of the distribution level shall finish the topic.

At this level, in a great number of developing countries, if not in all, the projects can be carried out by local personnel. This will, in less developed countries, mostly be the staff members of the utility itself. In more developed countries a local market will arise which can be served by local companies.

With the exception of large projects, the services of a consultant are not requested for such projects. It is however, particularly in the transitional stage, very important to establish technical standards and regulations which must be applied very strictly.

A consultant's help may be very useful in setting up and formulating such standards in close cooperation with the utility and, if possible, a local colleague.

Technical regulations should be established right down the line from the power plant to the consumer installation, ensuring safe and reliable operation as well as efficient stockkeeping. Defined technical rules and quality standards may, as a next step, encourage local firms to establish production of spare parts and small items in the country.

For a local engineering office it can become a permanent task, to supervise the proper fulfillment of these standards and regulations, to keep in touch with international colleagues and observe the world market in order to keep abreast of technical progress and development.

3. ORGANIZATIONAL STRUCTURES OF COOPERATION

From what has been presented so far it is clear that a precise description of required goods and services - in separate tender documents for various lots - increases the chance for local suppliers to submit a bid and, hopefully, participate in the project.

The farther this process of unpackaging goes, the smaller becomes the sector for which each individual supplier is held repsonsible. This means an increasing responsibility taken by the consultant for the project as a whole. This overall responsibilty is not restricted to merely technical subjects. It covers time schedule and cost control, proper execution of legal regulations, acceptance of performance, auditing of accounts, release of payments etc., etc. - in one word: The central function in project management.

It is not feasible to subdivide this overall responsibility. This fact must be reflected by the organizational structure of the relationship between customer, consultant and suppliers.

A basic outline of this structure is shown in the following graph (page 26).

This graph underlines that all participants - customer, authorities, financial aids - must and shall have a constant influence upon the project - but this influence can by no means be exerted in a direct way. The customer exerts his influence through the consultant, the consultant represents the customer's authority up e project, controlling and ensuring the proper execution of the cu r's ideas and intentions formulated in the legal contracts which are made directly between the customer and the various suppliers. This is very important, in fact it is the basic difference between the function of a consultant acting as trustee of the customer and an "Engineering contractor" acting as turnkey contractor for the entire project.

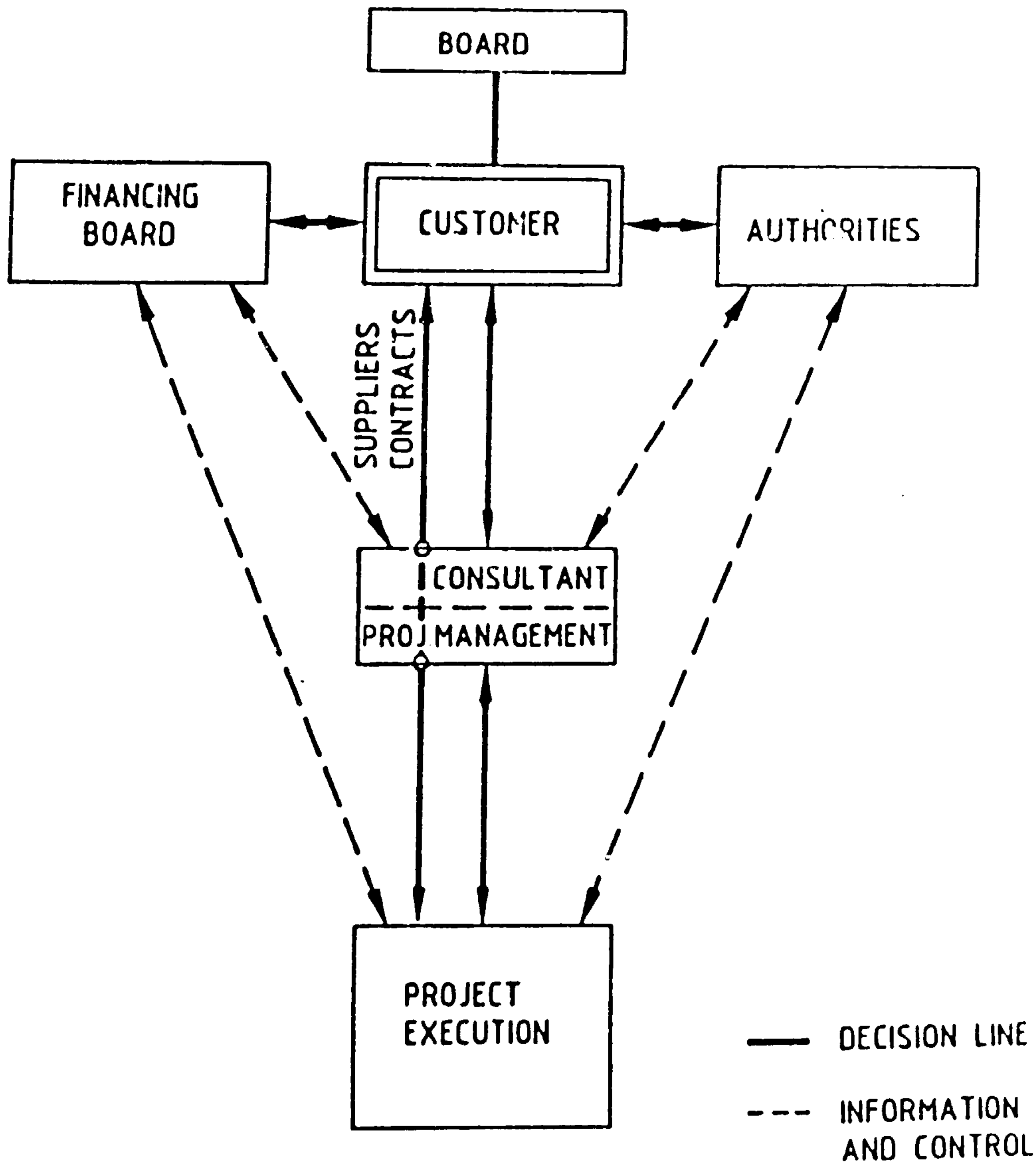

Fig.12: The consultant's role in the project structure

In a similar way, if cooperation with a local consultant is established, this cannot be done by installing new and separate arrangements between the customer and/or the suppliers in parallel to the organization lines of the consultant. The local engineer must be connected to the organizational structure, fulfilling his particular tasks and duties without interfering with the central responsibility of the leading consultant.

Again this may be illustrated by a graph which, additionally, shows the overall organizational structure of project management.

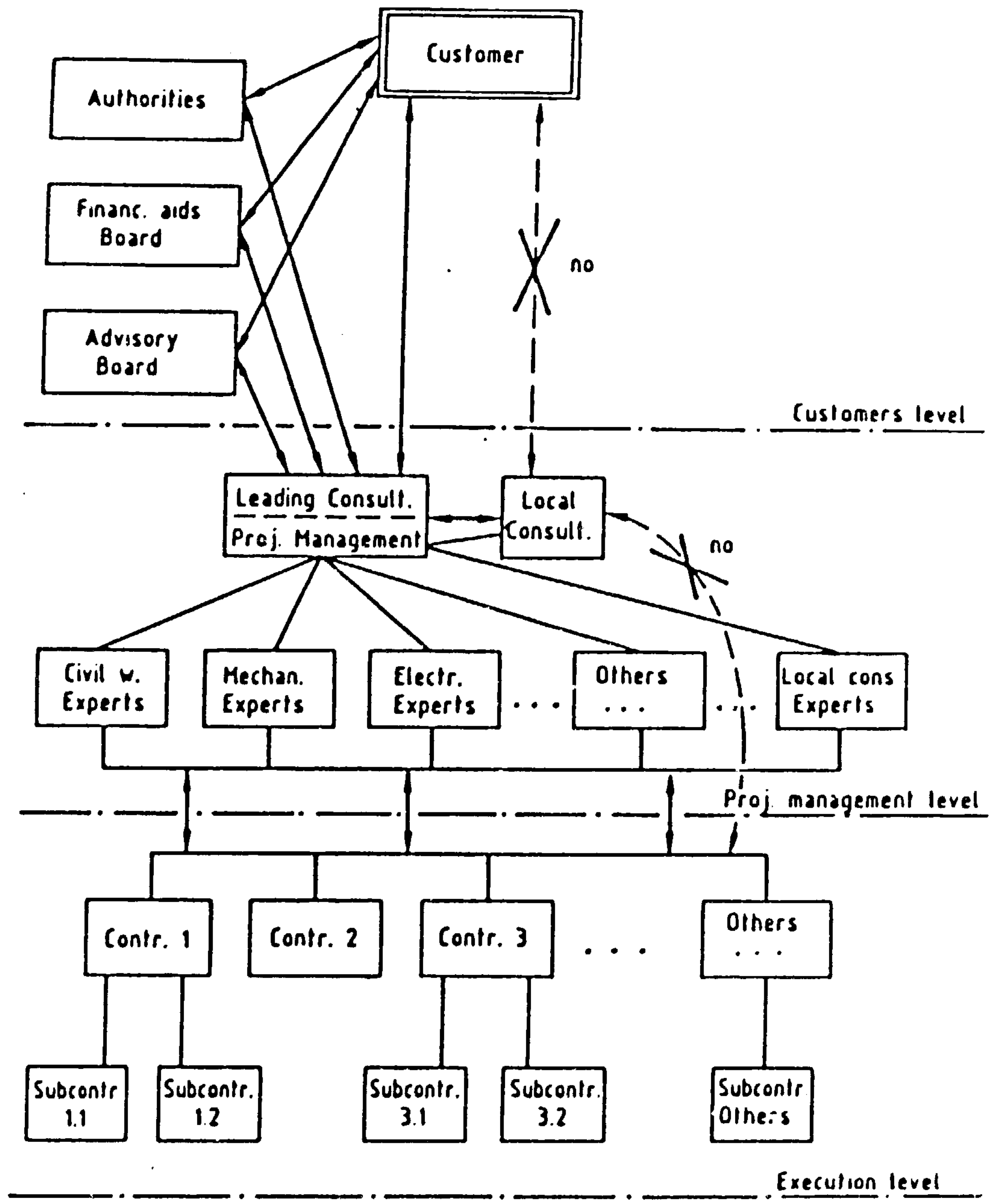

Fig. 13: Organizational structure of project management

This picture may finally reflect the role of the consultant: He brings his own knowledge, his experience and know-how into the project. But basically he acts as the customer's executor, representing his authority, transmitting his ideas and intentions to the project; and yet he is also a mediator between client and suppliers, balancing technical possibilities and local capabilities, desirable solutions and time and cost restrictions, ideas and reality, to the benefit and the success of the project.

Sources:

UNIDO - Paper 2137 V - Issue Paper II
Development of electric power equipment sector and technology unpackaging - 1985

UNIDO - Paper 2172 V/2208 V - TBLS
As above - Background to Issue II - 1985

R.F. Elsässer, FICHTNER Consulting Engineers: Das Projektmanagement aus der Sicht des Consultants - VDI-Report Nr. 512 - 1984

B.R. Söltner, FICHTNER Consulting Engineers: Managing Aid Funded Projects - Presentation at Middle East Economic Digest, London - 1984

Information and Data on various projects executed by FICHTNER Consulting Engineers in several countries - 1978 to 1985

List of Figures: