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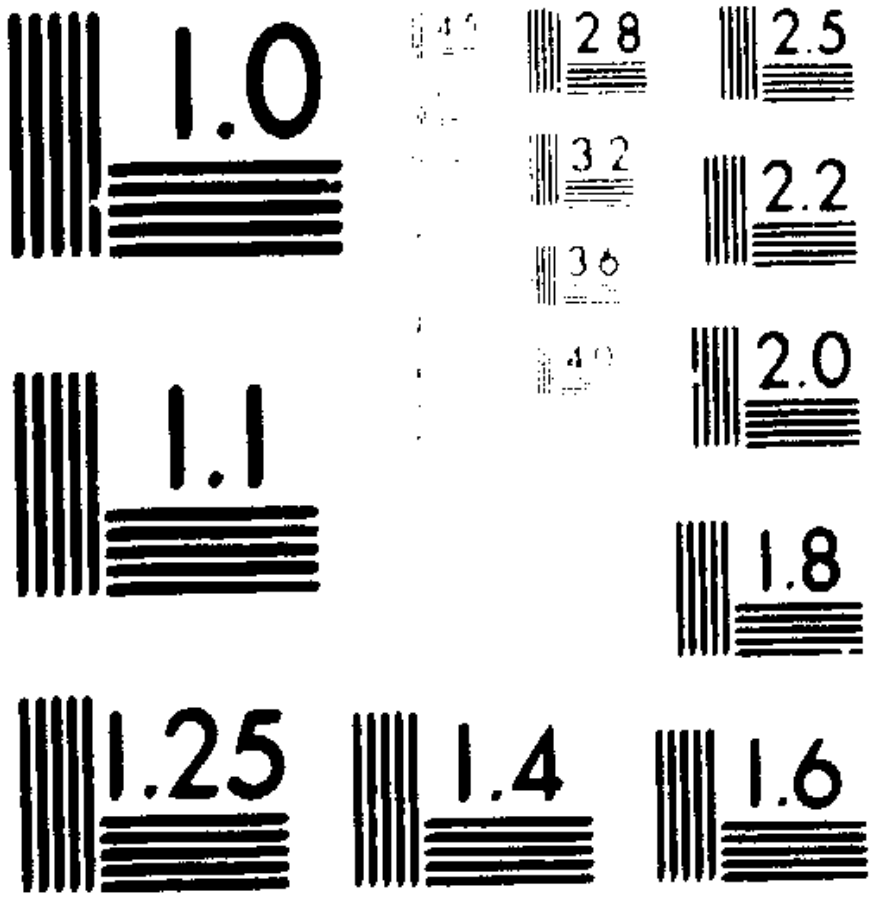

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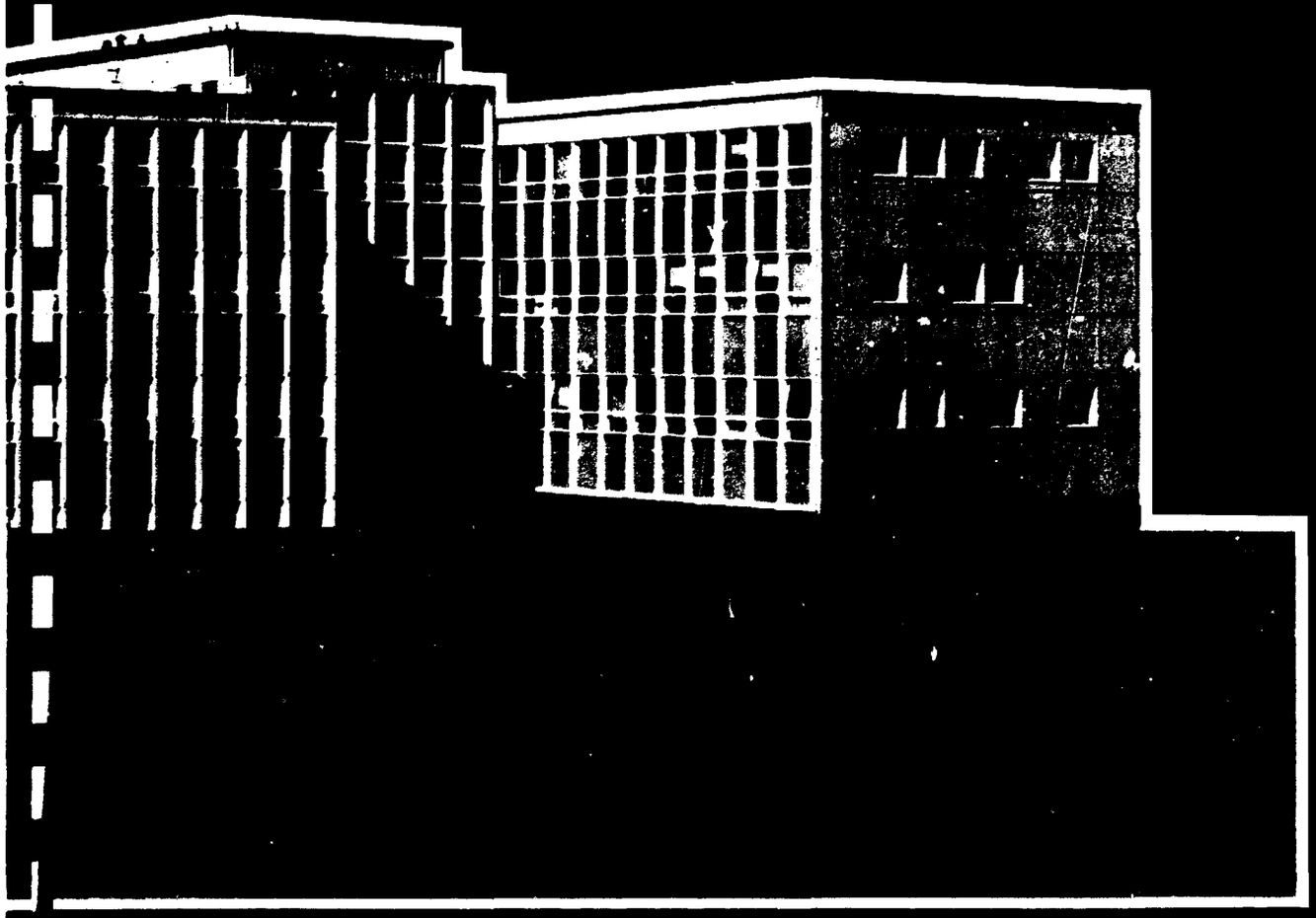

PROCESS DIVISION

BUILDING AND CIVIL WORKS DIVISION

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STRATEGIC ASSESSMENT

OF A

PREFEASIBILITY STUDY FOR SOUTH KOREA .

for

UNITED NATIONS INDUSTRIAL

DEVELOPMENT ORGANISATION (UNIDO)

JUNE 1980

UNIDO Contract
No. 80/52

RIC Project
No. PJ 5134

REED
INTERNATIONAL
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TABLE OF CONTENTS

GLOSSARY OF TERMS

ad	Air dry (10% moisture content)
adt	Air dry metric ton
adtpd	Air dry metric tons per day
adtpy	Air dry metric ton per year
bd	Bone dry (0% moisture)
bdkg	Bone dry kilogram
bdt	Bone dry metric ton
bdu	Bone dry unit of chips (2,400 pounds bone dry)
BKP	Bleached kraft pulp
cm	Centimeter
cif	Cost, insurance and freight
c and f	Cost and freight
cu m	Cubic metre
d	Day
DM	Deutschmark
dwt	Tons deadweight
fas	Free alongside ship
fob	Free on board
ha	Hectare
hr	Hour
IRR	Internal rate of return

kg	Kilogram
kg/adt	Kilograms per air dry metric ton
kg/sq cm	Kilograms per square centimeter
kg/hr	Kilograms per hour
km	Kilometre
kW	Kilowatt
m	Million or metre
min	Minute
MW	Megawatt
pa	Per annum
ROI	Return on investment
ROK	Republic of South Korea
SBK	Semi-bleached kraft pulp
t	Metric ton
tpd	Metric tons per day
tpy	Metric tons per year
UKP	Unbleached kraft pulp

CHAPTER 1 - SUMMARY AND CONCLUSIONS

1.1 - INTRODUCTION (Chapter 2)

In early 1980, H.A. Simons (International) Ltd of Vancouver, Canada, presented UNIDO and the Government of the Republic of South Korea (ROK) with a study. This study had evaluated four alternative means of securing Korea's future unbleached softwood kraft pulp requirements. Each of the four alternatives evaluated was shown to be unviable. UNIDO and the Government of the ROK therefore requested second opinions from two other consulting firms - Ekono Oy and Reed International Consultants Ltd. The present document represents the Reed opinion of the study.

The Simons study actually set out to evaluate three alternative options for securing an adequate economic supply of unbleached softwood kraft pulp for the ROK's paper industry. These were as follows.

a) Option A

Erection in Korea, either with entirely Korean equity capital or as a joint venture with Korean majority ownership, alongside the Donghae bleached kraft pulp mill, of an unbleached softwood kraft pulp mill utilising imported wood chips procured under long-term contracts from abroad.

b) Option B

Establishment in an overseas country, with softwood resources, of a new integrated timber production, wood extraction and pulp mill complex, as a joint venture with Korean majority ownership, which would export all or the major part of its production to Korea.

c) Option C

Acquisition in an overseas country, with softwood resources, of an integrated timber production, wood extraction and pulp mill complex as a joint venture, with Korean majority ownership, which would export all or the major part of its production to Korea.

In the event, it proved impossible to find any potential acquisition candidates of the Option C category. However Option B evaluations were made of mills in eastern Australia, California and British Columbia.

The four alternatives evaluated (ie: Korea, Australia, California and British Columbia) all proved unattractive investments at the 600 adtpd scale. Financial sensitivities were then applied to determine the effect of raising the pulp selling price by $50/adt and also increasing the scale of the mill from 600 adtpd to 800 adtpd. A combination of the two improvements brought the three overseas (ie: non-Korean) alternatives close to the viable range.

The Simons study concluded that a concerted effort should be made to develop a long range programme for the procurement and sustained supply of Korean pulpwood for Donghae. Once the economics and timing of such a supply was known, the expansion of the Donghae mill should be reconsidered.

Our approach to assessing the prefeasibility study has been essentially strategic. That is, we have looked at the 'big picture', mainly from commercial and technical viewpoints, in order to determine the best future actions for the interested parties.

1.2 - STRATEGIC BACKGROUND (Chapter 3)

1.2.1 Japanese Overseas Activities

The Japanese experience in facing up to a national wood shortage since the mid-1960's has been described, because it contains both pointers and warnings for the ROK. Also of relevance are Japanese future strategy plus any differences that could be distinguished between Japan's and the ROK's strategic position.

Japan's situation in forest products have progressively changed from near self-sufficiency in 1960, to imports in 1978 of 13.312 m cu m of wood (for pulping), 1.483 m t of pulp and 0.339 m t of paper and board products. In 1978, imported pulping wood represented 43% of total pulping wood consumption and 22% of Japan's total fibre requirement.

Japan's demand for imported pulping wood is cyclical, with the severe recession of 1975/6 causing her to negotiate cut-backs of about 30% in the volume imported from her main suppliers. The price movement of imported wood has also proved volatile, because sawmill activity is dampened earlier in the economic cycle than is paper demand.

To date, Japanese companies have participated in eight overseas pulp and paper ventures (page 3.6). Japan also has widespread wood production activities overseas (pages 3.8 and 3.9).

Of the existing overseas Japanese market pulp mills, all can produce bleached pulp (rather than unbleached only) and two-thirds of them have associated lumber operations. The latter will provide them with some relatively inexpensive chips as a part of their fibrous raw material. The equity stake taken by Japanese companies has ranged from 100% ownership right through the spectrum to small minority holdings (eg: 10%). These stakes in part reflect the relevant country's policy towards foreign ownership at the time the mill was established.

Japan's future strategy is to reduce its relative dependence on the USA, as a source of imported wood, and thus its vulnerability to concerted price increases, by develop-and-import projects in developing regions. More effort will be put into pulping the less conventional species. Future projects will involve the production of low added value grades (eg: newsprint) at mills located close to the source of the wood.

1.2.2 Significance for Korea

With the wood required to support a 600 adtpd Korean mill (around 1.0 m cu m pa) representing about 11% of Japan's softwood imports, the ROK is likely to meet tough Japanese competition for such wood sources. Given the Japanese pulp and paper industry's basic advantages, plus its greater leeway for putting up prices compared to Korea's mills (because of Japan's higher per capita income), it is likely that Japan could outbid the ROK. This could result in the ROK being left with the least advantageous sources of wood.

Probably the most important difference between the Japanese pulp industry and Donghae is that, while neither have any real control over the price of their imported wood, the Japanese have some control over their domestic wood supply. Thus the cost of exploiting that wood is close to actual cost. By contrast, the wood purchased on the Korean free market by Donghae is priced close to that of imported wood.

Basically the importation of wood is commercially unsound because wood chips have a fuel value and sea transportation is also energy-related. Further, there is mounting pressure in most countries against exporting wood in its raw state. Indonesia, where most of Korea's overseas forestry ventures are established, is one example of this.

Thus we foresee difficulties for the ROK in obtaining sources of chips plus insecurity of price were they to be established. However the volatility of Japan's requirement could provide the ROK with opportunities to purchase foreign wood during periods of low Japanese demand. This would help to conserve the ROK's wood resources. In order to take advantage of such opportunities, Donghae would need access to a harbour that could accept large chip carriers.

1.3 SPECIFIC COMMENTS ON PREFEASIBILITY STUDY (Chapter 4)

The prefeasibility study was examined in detail - but in the realisation that only significant alterations in the main cost components would change the conclusions of the study. The relative importance of these cost components can be seen from the exhibit on page 4.2.

As the outcome of our examination of the prefeasibility study, we believe the following modifications to the values employed are justified.

a) Fuel Costs. The study envisaged batch digesters at the Korean mill to provide flexibility for cooking different wood species. The evidence to date indicates that the existing batch digesters will provide adequate flexibility and that the expansion can have a Kamyr continuous digester. Similarly, the study envisaged cylinder dryers as in the existing mill. An airborne dryer would give lower fuel costs and, like parts of a Kamyr digester, could probably be manufactured in Korea. The combination of these two changes would reduce the fuel cost at the Korean mill by about $8/adt (ie: $1.68 m pa at the 600 adtpd level).

b) Capital Cost. The Australian mill (at $212.9 m) appears over-generously costed. This occurs mainly in the "effluent treatment and disposal" area, which seems too conservative by about $12 m. Tentatively a realistic estimate of the capital cost is about $195, although better definition of local costs might permit this to be reduced further.

c) Interest Costs. The study appears to ignore the benefits of export credit financing. This, plus alternative means of financing the local loan (eg: Euromarket or Asian Development Bank), is capable of reducing

the overall interest rate for the Korean mill to 10.5% pa (foreign loan) and 19% pa (local loan). These two changes would reduce the debt interest (Year 4) and amortization of construction interest (Year 6) by a total of about $25/adt pa. The three overseas mills would also benefit from export credit financing. The Australian mill would benefit slightly more than the two in North America. However, even for the Australian mill, the difference would not be very significant. The Australian mill will also have lower interest costs to the extent that the capital cost is lower.

d) Sensitivity Analysis. It is not clear from the study whether the capacity of any of the three overseas mills could actually be increased to 800 adtpd. The Australian mill sounds particularly doubtful. For any mill(s) that cannot be expanded, the 800 adtpd sensitivity becomes of academic relevance only. Incidentally, in the case of the Australian mill at 800 adtpd, it appears that the mill sales revenue employed is understated by $5/adt. Further, the sensitivity evaluating the $50/adt sales price increase should read $62.66/adt for the Korean mill in order to make all four cases comparable. This results from the various mark-up elements (ie: duty, L/C interest, etc) on the c and f price increase, and would give the Korean mill an additional $2.66 m pa at the 600 adtpd level. For the $100/adt price increase sensitivity, the difference is twice as large.

e) Pre-Production Costs. Reed was requested for its opinion on the higher pre-operating and start-up costs allowed for the Korean mill. The pre-operating costs are accounted for mainly by the additional wage and salary costs that would result from employing the trainees for up to nine months before start-up. The extra start-up cost would cover the additional expatriate personnel required. Thus both costs are in oder.

For the Korean mill, the above changes (totalling $33/adt at 600 adtpd or $31/adt at 800 adtpd) are insufficient to bring the project into the viable range.

For the Australian mill, the gross ROI is now increased to 13.8% (at the 600 adtpd level). This as compared with 12.0% for the Californian mill and 15.6% for the British Columbia mill. The wood price of the BC mill is rather theoretical and it would only take a 14% increase in wood price, over that

used in the study, to bring the ROI of the BC mill down to that of the Australian mill.

The present study has also identified four areas (ie: turpentine, harbour, hog fuel and chloralkali) where further study might improve the economics of the existing Donghae mill and the expansion.

1.4 REVIEW OF PREFEASIBILITY STUDY CONCLUSIONS (Chapter 5)

The conclusions of the prefeasibility study were reviewed in the light of the strategic background and modifications described in the two previous chapters.

1.4.1 New Overseas Mills (Option B)

Using Figures 1 and 2 of Appendix I, it was illustrated that UKP mills of both 600 and 800 adtpd are likely to be unviable unless specific compensating financial factors exist. Furthermore, UKP mills are less profitable than BKP mills, because any surplus capacity from the big southern US kraft linerboard mills can be exported as either UKP or kraft linerboard (for repulping as UKP). These mills have the advantage of cheap wood and this can serve to depress the price of UKP.

It was concluded that, rather than considering a 600-800 adtpd UKP mill overseas, the ROK would do better with a BKP mill of 800 adtpd (or larger). Further, the availability and price of the bulk of the mill's wood must be under the mill's control. An associated captive lumber operation would be one means of achieving this.

Such a mill should be acceptable to the ROK, since it would provide some of the ROK's softwood (and perhaps hardwood) BKP requirements. Production of UKP would be most acceptable to the mill when its selling price was not depressed by excess kraft linerboard capacity (corresponding to UKP being expensive, and possibly scarce, in Korea) or when the mill was short of orders for bleached grades. Thus the ROK's UKP supply would be secured during periods of tight market conditions.

None of the three overseas mills evaluated appears to fit well into the above formula for viability. The Australian mill seems the best of the three alternatives, but, whether it can be viable at the 320-570 adtpd level envisaged, remains to be determined.

The Australian federal government has recently undertaken a study jointly with Japan that has identified eight potential sites for new pulp mills. New Zealand, Chile, Guatamala, Peru and Indonesia are other countries where similar opportunities exist. Thus there is no shortage of potential pulp mill locations. The problem lies in the terms that can be negotiated and the associated risk. To the extent that the local partners 'play the market', the Japanese are likely to outbid the ROK. Thus, as we predicted in the context of obtaining overseas wood sources, there is the possibility that the ROK could be left with a choice between the least advantageous locations for a pulp mill.

The very smallest majority stake in an overseas mill that would attract local partners to provide the balance of the equity, would probably be around 65%. Such a stake in an 800 adtpd BKP mill, integrated with lumber production, would require an investment of around $60 m (at May 1980 prices).

1.4.2 Acquisition of Overseas Mill (Option C)

Any mill up for sale at the time of the prefeasibility study, when the market pulp market was relatively healthy, was unlikely to be a sound investment. Whether the forthcoming recession will be severe enough to produce some such investment opportunities remains to be seen. In assessing potential acquisitions, particular attention should be paid to the points made above - namely, control over wood supply and price, scale, bleaching capability and equity stake. In fact poor control over wood supply/price and the need for large sums of additional capital (to replace old equipment or install pollution control facilities) are the two main reasons for pulp mills being sold off.

1.4.3 Korean Mill (Option A)

There exists a high margin of doubt concerning the accuracy of the Korean mill financial return, because of the sharp increases in costs and prices prior to the study. For example, in January 1980, chip prices increased by 66% and oil prices by 59%.

We therefore reconstructed the financial return in mid-1977 and December 1979. In mid-1977, economic conditions were still depressed and the gross ROI of 1% (see page 5.8) was probably around the minimum the mill would have experienced. By contrast, the estimated 18% gross ROI in December 1979 was probably the maximum the mill would achieve. A complete economic cycle would give an average figure of around 8% gross ROI. Thus the financial return is even worse than the 12.8% gross ROI given in the study. The same

is probably true, to a lesser extent, for the three overseas mills.

1.5 KOREAN MILL BASED ON DOMESTIC WOOD (Chapter 6)

This chapter first assessed the viability of a Korean mill based on non-captive domestic wood. It then looked at the captive wood resource necessary to ensure viability.

1.5.1 Non-Captive Wood Basis

The long term supply/demand projection (page 6.2) shows that, even by the year 2030, the ROK will only have achieved 48% self-sufficiency in wood. Thus there will be an on-going deficit situation for the essential lifetime of any new pulp mill. Assuming the free market for wood purchasing continues in Korea, then the price of domestic wood is likely to remain close to that of the alternative - namely, imported wood.

The economics of a mill based on non-captive domestic wood will thus be similar to that of a mill based on imported wood.

1.5.2 Captive Wood Basis

The solution for Donghae is to establish, as close to the mill as possible, captive plantations that will supply it with a significant proportion of its future raw material. The whole question of establishing such a wood resource requires detailed study and the following figures should be regarded as very approximate.

The two provinces nearest to the mill (see map on page 6.4) - Geongbug and Geongnam - have sparsely stocked private forests of density 10.8 and 6.4 cu m/ha respectively. By contrast, the national forest has an overall stock density of 46.7 cu m/ha (page 6.6). Therein lies the opportunity to create plantations close to the mill - particularly as they will not interfere with the forest areas of the four other Korean groundwood mills.

Donghae has already studied the more intensive afforestation of the Yung Duhk region, which is located in the north of Geongbug province. A clear-cutting programme over 15 years would provide, on average, an annual pulpwood harvest for Donghae of 51,000 cu m of softwood and 37,400 cu m of hardwood. After that time, the plantation itself will yield 227,550 cu m pa (of both softwood and hardwood) by clear-cutting 1,637 ha annually.

When studying such future plantations, consideration must be given to the infestation of pine needle gall midge that is affecting about 300,000 ha to the north and east of Ulsan.

The prefeasibility study stated that the 600 adtpd Korean mill would be viable at a delivered wood price of ₡35/cu m. An updating, admittedly approximate, of a 1974 (last quarter) estimate of the cost of wood delivered from 400 km distant (Gangweon area) gives January 1980 values of ₡35/cu m for pine and ₡32/cu m for oak. In fact, based on experience elsewhere with plantations, a delivered price of around ₡25/cu m should be achievable.

On the basis of captive plantation wood at ₡25/cu m and domestic (or imported) wood at the study price of ₡56/cu m, a mean wood cost of ₡35/cu m would be achieved on a mix of 67% captive wood and 33% domestic/imported wood. Treating the existing Donghae mill similarly, sufficient captive plantation wood to support 640 adtpd of total production is required.

Since hardwoods grow more rapidly than softwoods, the expansion would have to be based essentially on hardwood plantations. Although Korean paper mills will be able to absorb 900 adtpd of hardwood pulp, in practice the mill will also produce some softwood pulp. In fact Donghae has already produced some softwood UKP. Ssangyong could evaluate its suitability for its requirements.

The initial evidence indicates that the hardwood choice lies between a rapid growing poplar species (populis alba), that gives a fairly weak pulp, and the slower growing less dense poplars, that give a stronger pulp. The corresponding areas required for plantations are 80,000 and 210,000 ha respectively. These areas are fairly modest relative to the 1,966,000 ha of private forest that exists in the two nearest provinces.

Donghae should also plan some long rotation (ie: softwood) species to grow through to sawmill size. The pulp mill would use the sawmill residues and the forest thinnings.

Indicative investment costs are ₡66 m (at May 1980 prices) for the 80,000 ha alternative and ₡97 m for the 210,000 ha alternative. About 56% of these costs is for establishment of the plantations and the balance (unescalated for inflation) is for tending. In addition there will be the cost (about ₡1,260 per ha) of establishing the long rotation softwood plantations.

Parenthetically, the $66 m figure is similar to the $60 m it was estimated would buy the minimum majority stake (65%) in an overseas 800 adtpd BKP mill.

The financial returns (as indicated by the Second 10-Year Forest Development Plan publication) are 16.7% pa compounded for poplar (over 15 years) and 6.9% pa for white pine (over 40 years). Since wood prices usually stay abreast of other prices, these are real returns (ie: over-and-above inflation). However, these returns are evidently based on selling the wood in a free market. In the present context, the return would depend on the actual price at which the wood was transferred to the pulp mill.

1.6 CONCLUSIONS AND RECOMMENDATIONS (Chapter 7)

In this study we have established that an overseas BKP mill, of capacity not less than 800 adtpd, could be a viable proposition. The mill must also have control over the bulk of its wood supply and price. Although there are several potential sites for such mills, the best sites are likely to be hotly contested by the Japanese. The possibility is that the ROK could be left with a choice between the least advantageous sites.

Of the three overseas sites evaluated, question marks exist regarding all three as to their suitability for a viable 800 adtpd BKP mill. The Australian mill is the firmest alternative, but it has the double disadvantage of evidentally not being larger than 200,000 adtpd and a high capital cost. Both factors lead to a high capital cost per ton of output. The main disadvantage of the North American alternatives is that the wood cost appears not to be under the mill's control.

Nevertheless it is recommended that the ROK keep abreast of these and other overseas projects, to the extent that this can be done without incurring heavy expense. In the event of their turning up a project with potential, according to the guidelines given in this study, they may wish to take expert advice. It is estimated that the minimum practical majority equity stake (65%) in an 800 adtpd BKP mill would cost about $60 m. A minority stake would cost correspondingly less.

The present Reed study has concluded that the Korean mill, based on imported wood, has even poorer economics than are indicated in the prefeasibility

study. Further, that the economics of a mill based on domestic Korean wood purchased on the free market would be similarly poor, since the price of this wood is similar to that of imported wood. In both cases, the mill has no control over its raw material cost.

The remaining alternative is a mill based on a part-captive wood supply. Unless an attractive overseas investment becomes available to the ROK, which seems unlikely, the development of captive plantations would be the soundest route to pursue.

Probably the most rapid way to establish such plantations would be to plant populis alba, or some other very fast growing species, for harvesting in the first four years. This assumes that the species' pulp is acceptable to the Korean paper mills. For the harvest in subsequent years, poplars giving a stronger pulp would be planted. In this way, a pulp mill could start up about 11 years after commencement of the planting programme. If the programme starts in 1981, construction of the expansion could commence in 1989.

Since the mill will be processing hardwoods, it will need bleaching facilities. The feasibility study should determine whether the production of dissolving pulp is justified. The existing Donghae mill and the expansion will also produce both UKP and BKP from domestic and imported softwoods. The domestic softwood will be made available by the clear-cutting programme, as well as from existing domestic sources. Subsequently they would be available from forest thinnings and sawmill residues. Imports of softwood chips may be feasible during periods of low demand by the Japanese.

Thus the first priority is for an in-depth study of the creation of captive plantations in the Donghae region. In addition, Donghae should study the items, mentioned on pages 4.9 and 4.10, that might improve its operation.

CHAPTER 2 - INTRODUCTION

In early 1980, H.A. Simons (International) Ltd of Vancouver, Canada, presented UNIDO and the Government of the Republic of South Korea (ROK) with a study. This study had evaluated four alternative means of securing Korea's future unbleached softwood kraft pulp requirements. Each of the four alternatives evaluated was shown to be unviable. UNIDO and the Government of the ROK therefore requested second opinions from two other consulting firms - Ekono Oy and Reed International Consultants Ltd. The present document represents the Reed opinion of the study.

The fieldwork in Korea was undertaken by Dr Roger Grant, Projects Director of Reed International Consultants Ltd, over the period 8-20th May 1980. During this period of fact-finding he was considerably assisted by the senior personnel of Ssangyong Paper Co Ltd and Donghae Pulp Co Ltd. Visits were made to their corporate headquarters in Seoul, the local UNIDO headquarters, the Donghae pulp mill at Onsan, and also to the Bureau of Forestry Management and the Forest Research Survey & Research Center (both in Seoul).

The Simons study actually set out to evaluate three alternative options for securing an adequate economic supply of unbleached softwood pulp for the ROK's paper industry. These were as follows.

a) Option A

Erection in Korea, either with entirely Korean equity capital or as a joint venture with Korean majority ownership, alongside the Donghae bleached kraft pulp mill, of an unbleached softwood kraft pulp mill utilising imported wood chips procured under long-term contracts from abroad.

b) Option B

Establishment in an overseas country, with softwood resources, of a new integrated timber production, wood extraction and pulp mill complex, as a joint venture with Korean majority ownership, which would export all or the major part of its production to Korea.

c) Option C

Acquisition in an overseas country, with softwood resources, of an integrated timber production, wood extraction and pulp mill complex

as a joint venture, with Korean majority ownership, which would export all or the major part of its production to Korea.

In the event, it proved impossible to find any potential acquisition candidates of the Option C category. However Option B evaluations were made of mills in eastern Australia, California and British Columbia. Other countries originally considered under this option were Chile, Fiji, Indonesia, Malaysia, Mexico and New Zealand, but they were not included in the terms of reference.

The four alternatives evaluated (ie: Korea, Australia, California and British Columbia) all proved unattractive investments at the 600 adtpd scale. Financial sensitivities were then applied to determine the effect of raising the pulp selling price by $50/adt and also increasing the scale of the mill from 600 adtpd to 800 adtpd. A combination of the two improvements brought the three overseas (ie: non-Korean) alternatives close to the viable range.

The Simons study concluded that a concerted effort should be made to develop a long range programme for the procurement and sustained supply of Korean pulpwood for Donghae. Once the economics and timing of such a supply was known, the expansion of the Donghae mill should be reconsidered.

Our approach to assessing the prefeasibility study has been essentially strategic. That is, we have looked at the 'big picture', mainly from commercial and technical viewpoints, in order to determine the best future actions for the interested parties.

To this end, Chapter 3 provides the international strategic background in the form of Japan's actions and experience while facing up to a similar wood shortage since the mid-1960's. This experience and their future plans contain both pointers and warnings for the ROK. Chapter 4 is the outcome of having examined the prefeasibility study in detail. It suggests several areas where the bases utilised in the study should be modified and examines the financial outcome of these modifications. Having set the strategic scenario and provided an improved concept of the options, Chapter 5 then reviews the conclusions of the prefeasibility study. First the overseas options are considered and then the Korean option. The latter leads into the possibility of a Donghae expansion based on Korean wood and this subject is dealt with in Chapter 6. The final conclusions and recommendations are to be found in Chapter 7.

In order to facilitate reading this report, it has generally adopted the bases used in the Simons study. Thus all costs and prices refer to January 1980 except where otherwise stated. Since certain May 1980 prices have been used, it is worth recording the value of the US dollar at both times.

	January 1980	May 1980
Korean Won	580	594
Australian Dollars	0.90	0.89
Canadian Dollars	1.17	1.18

To avoid any confusion between the two studies, the Simons study is referred to throughout as the "prefeasibility study", while the present report is referred to as the "Reed study". Where page numbers are given in the text between parentheses, they refer to pages in the prefeasibility study.

For those unfamiliar with the ROK, a map will be found as Exhibit 6.2 on page 6.4

CHAPTER 3 - STRATEGIC BACKGROUND

The Japanese have been facing up to the problem of a national wood deficit since the mid-1960's in essentially the same geographical area of the world as the ROK. We have provided this brief portrait of Japanese past actions and future plans because:

a) Japanese past actions contain some pointers for the ROK.

b) The ROK's future strategy should take into account Japanese future plans.

c) Any differences between Japan's strategic position and Korea's strategic position need to be identified.

3.1 JAPANESE OVERSEAS WOOD PROCUREMENT

3.1.1 Paper, Pulp and Wood Imports

Exhibit 3.1 sets the scene. In 1960, Japan was nearly self-sufficient in paper grade pulp, but imported 135,000 t of dissolving pulp. A relatively small quantity of wood was imported to complement the domestic supply. At that time she was also essentially self-sufficient in paper and board, for in 1960 she imported only 1,053 t.

Since then, paper and board imports have progressively increased - and in fact totalled 339,060 t by 1978. The increase would have been much greater had not both domestic pulping capacity and pulp imports also grown significantly. Thus paper grade pulp imports had increased to 304,216 t by 1965 and to 730,910 t by 1970. In order to support an increase in domestic pulp production of 3,637,204 t between 1965 and 1970, wood imports were increased by 4,824,000 cu m. It was thus during this period that the mass transportation of chips and pulpwood to Japan really commenced. By 1978, wood imports had reached 13,312,000 cu m, while pulp imports had grown to 1,483,496 t. The distribution of source countries for pulping wood is shown in Exhibit 3.2.

Pulping wood imports, expressed as a percentage of total Japanese pulping wood consumption, were 2% in 1960, 3% in 1965, 19% in 1970, 34% in 1973 and 43% in

EXHIBIT 3.1 - GROWTH OF JAPANESE PULP AND WOOD REQUIREMENTS

Year	Domestic Pulp Production (t)		Pulp Imports (t)		Pulping Wood Imports (cu m)		
	Dissolving	Paper Grades	Dissolving	Paper Grades	Softwood	Hardwood	Total
1960	378,349	3,153,488	135,175	11,705	174,000	19,000	193,000
1965	469,299	4,694,653	202,475	304,216	417,000	44,000	461,000
1970	554,020	8,247,136	185,903	730,910	4,398,000	887,000	5,285,000
1978	321,295	9,070,350	214,258	1,483,496	8,794,000	4,518,000	13,312,000

EXHIBIT 3.2 - SOURCES OF JAPANESE PULPING WOOD IMPORTS

(in '000 cu m)

Year	USA	USSR	Australia	Malaysia	New Zealand	Indonesia	Other	Total
1960 - softwood	-	173	-	-	-	-	1	174
- hardwood	-	19	-	-	-	-	-	19
1965 - softwood	253	142	-	26	-	9	6	417
- hardwood	-	25	-		-			44
1970 - softwood	4,072	143	-	-	153	-	30	4,398
- hardwood	18	113	-	572	5	25	153	886
1978 - softwood	6,905	629	-	-	400	-	871	8,805
- hardwood	352	301	2,720	434	56	83	578	4,524

1978. The 1978 figure breaks down into 56% of total softwood consumption and 29% of total hardwood consumption. In 1978, Japan's total fibre consumption was composed of 52% domestic pulp, 8% imported pulp and 40% waste paper. Thus about 22% of her total fibre requirement was met from imported wood.

The export chip market has proved volatile for the Japanese and their suppliers, because the factors influencing supply and demand are out of phase in the economic cycle. Chip availability is an early casualty in an economic cycle, as artificially high interest rates reduce housing starts in North America (and elsewhere) and thus sawmill activity. However paper consumption, and thus the demand for chips, continues to grow for several quarters until high interest rates finally have their desired influence on consumption. The peak of the economic cycle is characterised by excessive prices for chips, pulp and paper. In the latest cycle, this peak was reached in the first half of 1980. About the time the cycle peaks, interest rates are relaxed and housing starts gradually pick up. However paper consumption has by then been dampened. The price of chips and market pulp then either stay constant or decline, depending on the severity of the ensuing recession. Thus the Finnish and some Swedish manufacturers have recently announced unchanged pulp prices for the third quarter of 1980.

This pattern is illustrated by Japan's experience over the previous economic cycle. By mid-1973 severe shortages of chips were building up in British Columbia and an embargo on some exports was subsequently imposed. In early 1974, Japan bought 200,000 cu m of pine wood, damaged by gales, from West Germany. Its willingness to buy from so far distant a source was a measure of the wood shortage it was experiencing.

By early 1975, paper consumption was dropping and Japan was negotiating with Australia, the USA and USSR for reduced chip shipments amounting to around 30% of the contracted volume. These reductions were obtained and followed, at some length, by price reductions. The BC government subsequently lifted its embargo on chip exports. In 1977, when the chip market was still weak, Japan sold off (or converted to other uses) about 14 of her chip carriers. (In 1979 she had 54 chip carriers with a total deadweight of 1,997,665 t. That gives an average size of 37,000 t dwt). At the same time, Weyerhaeuser were offering a small discount for chips if the contractual volume was taken up.

Since 1977, Japanese paper consumption has progressively increased, while interest rate rises in the second half of 1979 have depressed housing starts. The price pattern (fas basis for US Douglas fir chips) has behaved accordingly. From $50/bdu, during the first half of 1974, the price increased in the second half to $60/bdu. Protracted negotiations ensued and, for the first half of 1976, the price was reduced to $53/bdu. The market remained relatively stable until the end of 1979, when rising paper consumption and declining sawmill activity permitted two rapid price increases to be pushed through. The price for the first quarter of 1980 thus became $92/bdu. The corresponding price for hemlock was $115/bdu. Japanese newsprint producers responded by raising the domestic price of newsprint by 33-40% (ie: by $170-195/t) to $695/t.

How is Japan able to accommodate price increases in its raw material that are essentially beyond its control? The answer lies in a combination of factors. One of these is the size distribution of the companies making up Japan's pulp and paper. Thus the two largest pulp producers account for about 25% of domestic pulp output, while the ten largest account for about 70%. The size of the mills themselves is generally large, so that economies of scale help to offset raw material costs. One mill alone (Taio's Iyo Mishima City mill) produces 2.36 m tpy of pulp and paper from 80% imported wood. This is equivalent to about 17% of all pulping wood imports. Further, Japanese pulp companies control significant quantities of domestic woodland and thus this part of their raw material is under their control.

3.1.2 Overseas Ventures

In order to provide some of Japan's imports, Japanese companies have participated in eight overseas mills to date and a further two projects are at the planning/discussion stage. The most recent of these, namely a purchase of 33% of CIP's Dalhousie mill, was only announced in mid-June 1980. These mills are outlined in Exhibit 3.3. The following points will be noticed about the "Production" column data.

a) Six, out of the eight, existing mills produce market pulp rather than paper. The other two mills both produce newsprint. The two mills planned will produce market pulp.

b) Four, out of the six, existing pulp mills have an associated lumber operation. This will provide them with a proportion of relatively inexpensive chips in their raw material furnish.

EXHIBIT 3.3 - JAPANESE PULP AND PAPER MANUFACTURING VENTURES OVERSEAS

Venture	Location	Joint Venture Partners		Production
		Name	Holding	
Alaska Lumber & Pulp Co Ltd	Sitka, Alaska, USA	Alaska Pulp Co Ltd[a]	100%	Lumber Dissolving sulphite pulp (480 mtpd)
North Pacific Paper Co	Longview, Washington, USA	Jujo Paper Weyerhaeuser	10% 90%	Newsprint (190,000 mtpd) (PM2 to start-up 1981)
Crestbrook Forest Industries Ltd	Skookumchuck, B.C, Canada	Honshu Paper Manuf. Co Ltd Mitsubishi Corp Crestbrook Timber Ltd	26% 26% 48%	Lumber Softwood bleached sulphate pulp (410 mtpd)
Finlay Forest Industries Ltd	Mackenzie, B.C, Canada	Jujo Paper Cattermole Timber B.C.F.P	14.6% 42.7% 42.7%	Lumber Refiner groundwood pulp (290 mtpd) (25,000 mtpy being added; start-up 1981)
Cariboo Pulp & Paper Co	Quesnel, B.C, Canada	Daishowa Paper Marubeni Corporation Weldwood of Canada[c]	50% 50%	Softwood bleached sulphate pulp (680 mtpd) (Additional 30,000 mtpy being considered)
Carter Oji Kokusaku Pan Pacific Ltd	Nepia, North Island, N.Z	Oji Paper Sanyo-Kokusaku Pulp Carter Consolidated Ltd	20% 20% 60%	Lumber Refiner groundwood pulp (600 mtpd)
Cellulose Nipo-Brazileira (Cenibra)	Minas Gerais, Brazil	Japan Brazil Paper & Pulp Resources Development Co (JBP)[d] Ca. Vale do Rio Doce (CVRD)	49.4% 50.6%	Eucalyptus bleached sulphate pulp (750 mtpd)
Quesnel River Pulp Co Ltd	Quesnel, B.C, Canada	Daishowa West Fraser Timber	50% 50%	Mechanical pulp (175,000 mtpy) (Start-up planned 1982)
Toypack	(Northwest, USA)	Toyo Pulp Pack River	50%[e] 50%	Bleached chemical pulp (450-635 mtpd) (Tentative plans; start-up 1983-84)
New Brunswick International Paper	Dalhousie, N.B., Canada	Oji Paper Mitsui Canadian International Paper	33%[f] 67%	Newsprint (247,000 mtpy) (91,000 mtpy being added)

Notes:

a 22 major Japanese paper and rayon manufacturers

b Twenty-year agreement, ending 30.9.87, for Honshu and Mitsubishi to buy all of pulp production

c Wholly-owned subsidiary of Champion International

d JBP is owned 40% by the Japanese goverment's Overseas Economic Cooperation Fund, and 60% by C Itoh and 15 Japanese paper companies

e Option for another company to take one-third of total equity

f Purchase of part share of existing mill announced mid-June 1980

c) All of the chemical pulp mills have bleaching facilities. This does not, of course, prevent them from producing unbleached grades when so desired.

d) The scale of the existing chemical pulp mills ranges 410-750 mtpd.

e) The total installed market pulp capacity is about 1,050,000 tpy. This is around 60% of Japan's 1978 pulp imports of 1,697,754 t, although, of course, not all this tonnage will be destined for Japan.

With regard to the proportion of equity held by Japanese parties, this ranges from complete ownership (Alaska), through a collective majority stake (Crestbrook), a 50-50 basis (Cariboo, Quesnel, and Toypack), large minority holdings (Carter, Cenibra and New Brunswick) to small minority holdings (North Pacific and Finlay). As will be seen from the footnotes, the larger Japanese stakes are in fact subdivided between a number of participants. The stake in each mill will in part reflect the relevant country's policy towards foreign ownership at the time the mill was established.

3.1.3 Future Strategy

What indications are there of Japanese strategy in the future? The Japanese realise that a big proportion of their supply comes from the USA (including 78% of their softwood) and that a large price increase in that country has a disproportionate effect on their raw material costs. They therefore intend to seek additional sources in other countries. Three other pointers towards their future policy are.

a) Further investment will be made in develop-and-import projects in developing areas. Their present ventures are shown in Exhibit 3.4 and their trial plantings in Exhibit 3.5.

b) More effort will be put into pulping the less conventional species. For example, they are at present trying mixed tropical hardwoods from Papua, New Guinea.

c) Future projects will involve the production of low added value products (eg: newsprint) at mills located close to the source of the wood.

EXHIBIT 3.4 - JAPANESE WOOD PRODUCTION VENTURES OVERSEAS

Venture	Location	Japanese Companies Involved	Business
Daishowa (M) Wood Products Sdn Bhd	Port Swettenham, Selangor, Malaysia	Daishowa Paper; Shiko Shoji	Disused gumwood chip production
Sarawak Wood Chip Sdn Bhd	Rajang, Sarawak, Malaysia	Kohjin Co	Mangrove chip production
Sharikat Bakau Sabah Sdn Bhd	Tawau, Sabah, Malaysia	MDI (a development company jointly established by Kohjin, Jujo Paper, Kanzaki Paper, Sanyo-Kokusaku Pulp & Nippon Pulp)	Mangrove chip production
Jaya Chip Sdn Bhd	Sandakan, Sabah, Malaysia	MDI (see above)	Mangrove chip production & afforestation
Oji Malaysia Plantation Sendirian Bhd	Johore, Malaysia	Oji Paper Co	Afforestation
Harris Daishowa (A) Pty Ltd	Eden, New South Wales, Australia	Daishowa Paper; C Itoh & Co	Eucalyptus chip production
Jant Pty Ltd	Madang, New Guinea	Honshu Paper Co	Hardwood chip & lumber production
Nelson Pine Forest Ltd	Nelson, South Is., New Zealand	Tokai Pulp Co	Softwood & hardwood chip production
Empreendimentos Florestais S.A.	Espirito Santo, Brazil	Japan Brazil Paper and Pulp Resources Development Co*	Eucalyptus afforestation for chip and pulp production in the future
Associated Wood Products Co	Juron, Singapore	Settsu Paper Board	Lauan chip production

Note:

JBP is owned 40% by the Japanese goverment's Overseas Economic Cooperation Fund, and 60% by C Itoh and 15 Japanese paper companies

EXHIBIT 3.5 - JAPANESE TRIAL PLANTINGS OF PULPING SPECIES OVERSEAS

Venture	Location	Japanese Companies Involved	Date and Planted Area (ha)	Species Planted
Oji Malaysia Plantation Sdn Bhd	Paloh, Johor State, Malaysia	Oji Paper Co	1971-75 451	Pinus caribaea, Pinus merkusii, Pinus oocarpa
Daishowa Wood Products Sdn Bhd	Rawang, Selangor State, Malaysia	Daishowa Paper Mfg. Co	1971 23	Pinus caribaea
South East Asia Afforestation Sdn Bdh	Simpang Wa Ha Johore State, Malaysia	Daishowa Paper Mfg. Co	1974-75 110	Pinus caribaea
P.T. Zedsko Indonesia	Malili, Selawesi, Indonesia	Sanyo-Kokusaku Pulp Co	1972-74 110	Agathis sp. and 16 various hardwood species
Jant Pty Ltd	Madang, Papua, New Guinea	Honshu Paper Co	1974 50	Eucalyptus deglupta
Stettin Bay Lumber Co Pty Ltd	Hoskins, New Britain, Papua, New Guinea	Sanyo-Kokusaku Pulp Co	1975-77 257	Kamarere
Sharikat Bakau Sabah Sdn Bhd	Sandakan, Sabah, East Malaysia	MDI*	1974-76 83	Pinus caribaea
Under the direct management of JOAA	Kolombangara Is and Solomon Islands	Japan Overseas Afforesting Association**	1973-75 300	Gmelina arborea, Terminalia brassii, Albizzia falcata

Notes:

* JBP is owned 40% by the Japanese government's Overseas Economic Cooperation Fund, and 60% by C Itoh and 15 Japanese paper companies

** Japan Overseas Afforesting Association (JOAA) is an overseas pulpwood planting organization jointly established by 11 leading paper companies and a forestry company in Japan

3.2 SIGNIFICANCE FOR KOREA

The main impression from the above description is, of course, Japan's high level of domination of Korea's potential wood supply area. A 600 adtpd softwood pulp mill would require around 1,000,000 cu m pa of solid wood. This is equivalent to about 11% of Japan's softwood imports. Wherever Korea sought such source(s) of wood, she would probably be competing against Japan. In most cases the local party is likely to sign up with the highest bidder. Since Japan's mills have more leeway for putting up their prices than Korea's mills, because of Japan's significantly higher per capita income, plus the other advantages described above, it is likely that Japan could outbid the ROK. This could result in the ROK being left with the least advantageous sources of wood.

The Japanese experience illustrates that they have no real control over the price of their imported wood. Probably the most important difference between the Japanese pulp industry and the Donghae mill is that the former has a proportion of its raw material under its own control. Thus the cost of exploiting that wood is close to actual cost, rather than being pitched at the inflated level of imported wood. Donghae has no control over the Korean wood supply at present, since the wood is purchased on the free market from outside sources.

There are also two fundamental reasons for this form of supply being unsound. Firstly, wood chips have a fuel value. North America is looking increasingly at burning wood residues, while Japan is the world's largest importer of coal and the second largest importer of oil. At the international oil prices prevailing in January 1980, wood residues had a fuel value of about $50/bdu. Thus the price of $53/bdu, that prevailed until the end of 1979, automatically became untenable as the oil price went up. Secondly, transportation by sea, which accounts for about one third of the delivered cost of wood, is fuel-intensive. Thus the delivered price of chips is likely to rise by more than the price of pulp as fuel prices progressively increase.

In addition, there is mounting pressure in most countries against exporting wood in its raw state. For example, in Indonesia, the country in which Korean forestry operations are best established, the government is scrutinizing anew the progress of foreign operators towards Indonesianization. The relevant decrees require that within ten years, a minimum of 40% of log processing is done in Indonesia and also that at least 51% of the equity of such undertakings is in Indonesian hands.

Thus we foresee difficulties for the ROK in obtaining sources of chips plus insecurity of price were they to be established.

However, the very nature of the Japanese trade could provide opportunities for Korea. The 1975 recession was particularly severe and such severity is unlikely to occur frequently in the future. In addition, chip suppliers are likely to take steps to reduce the volatility of their trade with Japan. Nevertheless, the underlying phase difference between high sawmill activity and high paper demand will remain. Korea should thus be able to pick up chips from Japan's suppliers during Japanese recessional periods. This would help to conserve her wood resources. In order to take advantage of such opportunities, Donghae would need access to a harbour that could accept large chip carriers.

Regarding the production profile of Japan's overseas mills, it is interesting to note that none of them are purely unbleached mills, since they all have bleaching facilities. This is related to the fact that bleached pulp mills are more profitable than unbleached mills - a fact we shall amplify on in Chapter 5. It is also interesting to note that four, out of the six, existing pulp mills have associated lumber operations. This is an obvious benefit in terms of raw material cost.

One final point. Namely, the size of the Japanese overseas mills (410-750 tpd). Historically it was possible to be competitive on a relatively small scale. However increases in obligatory environmental capital spending, in combination with the most advantageous mill sites already having been taken up, have meant a move to larger scale mills.

CHAPTER 4 - SPECIFIC COMMENTS ON PREFEASIBILITY STUDY

The prefeasibility study concluded that all four projects were unviable. To change this conclusion would require fairly large alterations to the economics of manufacture. In assessing the correctness of the study, we therefore looked primarily at the main cost components, since only they are capable of providing sufficiently large alterations.

Exhibit 4.1 shows the various manufacturing costs. They are as provided in the study, but with the difference that they are now all expressed as $/adt of finished pulp. This facilitates identifying their relative contribution to the total cost. The costs utilised are those at full production (ie: "Year 6" in the study), except that debt interest has been taken at "Year 4".

Evidently wood is the most significant variable cost. Energy is also particularly significant for the Korean mill. Among the fixed costs, labour is relatively costly in the overseas mills, but not in the Korean mill. Among the financial costs, both interest and depreciation are very significant. They in turn are derived principally from the capital cost and the interest rate structure. These items also determine the construction interest.

We will now describe areas in the prefeasibility study where we believe modifications to the values employed are justified.

4.1 FUEL COSTS

It will be seen from Appendix 2 of the study, that a Kamyr continuous digester and an airborne dryer were envisaged for the three overseas mills. However the Korean mill was to have batch digesters and cylinder dryers. This not only pushes up the total steam requirement of the Korean mill, but also gives it an adverse high pressure-to-low pressure steam ratio. The latter results in 50,800 kg/hr of steam at 64 kg/sq cm being reduced to a pressure of 4.5 kg/sq cm, without any useful power-generating work being done.

Our proposed modification to the mill's concept is for the type of digester and dryer at the Korean mill to be the same as at the overseas mills. This is based on the following reasoning.

EXHIBIT 4.1 - SUMMARY OF PRE-FEASIBILITY STUDY UNIT MANUFACTURING COSTS

(in US$/adt of finished pulp)

	Korea		Australia		California		British Columbia	
Production Scale (adtpd)	600	800	600	800	600	800	600	800
Pulpwood and Chips	267.90		108.30		157.17		117.80	
Salt Cake	14.19		9.90		4.95		3.90	
Limestone	0.90		1.96		0.84		0.30	
Fuel Oil	60.91		-		-		11.10	
Natural Gas	-		-		6.60		-	
Coal	-		7.38		-		-	
Hog Fuel (purchased)	-		-		4.50		-	
Power (purchased)	-		1.55		-		1.60	
Water	1.47		9.30		5.00		-	
Materials and Supplies	20.00		23.00		20.00		23.00	
Total Variable Costs	365.37		161.39		199.06		157.70	
Labour	4.76		25.32		31.43		27.67	
Local Taxes	4.76		0.48		9.52		9.52	
Insurance	1.43		1.43		1.43		1.43	
Overhead	9.55		13.36		12.12		13.93	
Total Fixed Costs	20.50		40.59		54.50		52.55	
Sub-Total (Variable and Fixed Costs)	385.87	382.53	201.98	192.19	253.56	242.79	210.25	199.97
Depreciation	51.80	45.62	76.03	67.28	119.91	106.13	75.79	66.85
Debt Interest (Year 4)	106.31	93.73	96.75	84.05	73.42	63.29	78.81	68.88
Amortization of Deferred Charges	5.52	4.29	3.81	2.86	3.81	2.86	3.81	2.86
Amortization of Construction Interest	9.01	5.78	8.80	6.49	6.50	4.79	7.19	5.30
Total Financial Costs	193.14	149.42	185.39	160.68	203.64	177.07	165.60	143.89
Total Ex-Mill Cost	579.01	531.95	387.37	352.87	457.20	419.86	375.85	343.86
Sales Revenue (ex-mill)	497.00	497.00	346.50	346.50	355.50	355.50	355.50	355.50

4.1.1 Digester

Apparently batch digesters were installed at the existing Donghae mill in anticipation of the mill receiving a wide range of wood species. The species could then be cooked separately as required.

As the mill rationalizes its sources of wood supply, the number of different species will probably decrease. Development of the local domestic wood supply will also serve to reduce the number of species received. In addition, Donghae's initial experience indicates that all its hardwood species and all its softwood species can be cooked together.

The mill's more detailed evaluation of the subject would be of value, but the indications are that a Kamyr continuous digester can be justified for the expansion. This will still leave the mill with some flexibility for separate cooking, since the existing batch digesters will represent 33% of total mill digester capacity if the expansion is at the 600 adtpd level, or 27% if it is at the 800 adtpd level. It is possible that parts of a Kamyr digester could be manufactured in Korea.

4.1.2 Pulp Dryer

Normally airborne dryers have a lower capital cost than cylinder dryers, but this is probably not the case when the cylinder dryers are made in Korea. Apparently the reason for installing cylinder dryers at the existing Donghae mill was to further the development of this technology in Korea.

It is proposed that, for the expansion, a suitable Korean manufacturer negotiates with one of the airborne dryer manufacturers to produce an airborne dryer in Korea. This will benefit Korean manufacturing industry as well as giving the mill a lower fuel requirement.

4.1.3 Fuel Saving

The outcome of these two modifications is to change the steam and power requirements as follows.

	Prefeasibility Study	Reed Modification
Process Steam Demand - 12.5 kg/sq cm	57,000	89,875
(kg/hr - 4.5 kg/sq cm	131,900	84,400
- total	188,900	174,275
Power Demand (kW)	16,000	17,000

The total steam requirement is thus reduced slightly and the high pressure-to-low pressure steam ratio is more favourable. This assists in generating the additional 1,000 kW of power. The outcome is a saving in fuel oil of $8.50/adt pulp. There will be an associated small incremental increase in cost for the larger turbine, but this will be somewhat offset by the lower capacity power boiler required.

4.2 CAPITAL COST

In evaluating the capital cost, it should be appreciated that the nominal capacity refers to a 350-day operating year. Thus the 600 adtpd mill operating over 350 days produces 210,000 adtpy. Since such a mill would be expected to average about 90% availability once steady running conditions had been reached, the equipment itself must be capable of 667 adtpd on a sustained basis. Similarly, the 800 adtpd mill equipment must be capable of 889 adtpd.

Of the four alternatives, the Australian mill appears to be over-generously costed (page 100). In particular, the "effluent treatment and disposal" cost is high. In fact this supply corresponds almost exactly to that allowed for the Californian mill, except for the 20 km pipeline. The cost for the Californian mill is about right, but the difference in the "mechanical" allowance between the two mills is $15.095 m. Our estimate of the cost for this pipeline (in iron to withstand pumping pressure) plus excavation plus two pumping stations is $3 m. Thus this item appears to be too high by about $12 m.

Taking into account this and other conservative estimates, plus the fact that the "contingencies" magnify them by 11.1%, we believe that the capital cost estimate could be realistically reduced from $212.9 m to $195 m. Better definition of the site plus a knowledge of local costs might permit it to be reduced further.

4.3 INTEREST COSTS

The prefeasibility study used the following interest rates for the long term loans (page 103).

	Korea	Australia	California	British Columbia
Local Portion	21% (55%)	)	)	)
Foreign Portion	12% (45%)	)12%	)12%	)12%
		)	)	)

Pulp mills are capital-intensive and thus a small alteration in interest rate makes a significant difference to the economics. One would therefore, other things being equal, structure the loans to provide low interest rates.

We believe that the interest rates used for the projects are too high, because export credits (ie: buyer's credits or supplier's credits) could be used for a proportion of the loan. We will consider first the Korean mill, and then the overseas mills collectively.

4.3.1 Korean Mill

The foreign portion of the existing Donghae mill was financed by a mixture of Finnish credit (in US dollars at 8.0%) and German credit (in DM at 8.75%). These export credit interest rates do not change much with world interest rates, and in fact the Finnish interest rate in January 1980 was still 8.0%.

Domestic Korean interest rates are high relative to international interest rates and they accounted for 55% of the loan capital. It is often possible to negotiate a contribution to the local loan as a part of the export credit. Thus, for example, the United Kingdom's ECGD (Export Credit Guarantee Dept) will allow about 20% of the value of the foreign loan towards the local loan. In our experience this is a fairly typical figure. Alternatively, the local loan could be financed on the Euromarket. Another possibility is the Asian Development Bank. While they normally finance the foreign exchange costs of projects, they can include foreign exchange components of local procurements. In January 1980 their interest rate was 8.1%.

Financing a part of the local loan in foreign exchange would have to be weighed against the likely further devaluation of the Korean Won. However, were the additional financing to be in US dollars, since imported pulp prices

are also quoted in US dollars, there would be a built-in partial correction against such changes in currency parity. This should be evaluated as a sensitivity in the feasibility study for the final mill concept.

4.3.2 Overseas Mills

The 12% utilised in the prefeasibility study is a fair interest rate for locally financed projects. However these mills can also benefit from export credits to the extent that they import equipment for the project. It is estimated that the Australian mill would import around 15% more of the relevant equipment than would the other two overseas mills. It could thus benefit more from export credits by about this amount.

4.3.3 Interest Cost Saving

Before deciding on revised interest rates, we must make the two following qualifications to the above.

a) Export credits are specific to a given country. It is evident that the political events of May have temporarily hurt Korea's international credit rating. Some conservation in the use of interest rates is therefore indicated.

b) For some years there have been efforts, led by the USA, to harmonise the export credits of OECD nations at international interest rate levels. As an outcome of this, there will be an all-round increase of 0.75% on July 1st 1980. The US is seeking a minimum increase of 2%. This increase is unlikely to be reflected in the price of pulp over the short term. However, if carried to international interest rate levels, it would have a depressing effect on the installation of new pulping capacity. This in turn would have an influence on pulp prices.

Taking into consideration the above, we feel that a suitable foreign loan rate for Korea is 10.5% rather than the 12% used in the study. Similarly the effective rate of the local loan should be 19% (rather than 21%) on the assumption that a 20% contribution at export credit interest rate levels can be obtained. These two changes would reduce the debt interest (Year 4) and amortization of construction interest (Year 6) by a total of about $25/adt.

The effect of export credit financing on the three overseas mills would be less, because imports represent a smaller proportion of the total supply and their capital burden is lower. However it would improve their profitability

slightly, with the Australian mill benefitting more than the two in North America.

4.4 MISCELLANEOUS POINTS

4.4.1 Australian Mill Sales Revenue at 800 adtpd

The prefeasibility study states (page 116) that the mill net sales price for the Australian mill is $346.50/adt. This value has been used for all three of the 600 adtpd Australian cases evaluated, but, for the 800 adtpd capacity mill, a value of $341.50/adt has been used (see the Case 22 computer print-out). Since the same mill net sales price has been used for both the 600 adtpd and 800 adtpd scales for all three of the other cases, and there is no mention of an exception being made in this case, it is believed that this is an error. The outcome of revising the value to $346.50/adt is to increase the revenue from sales by $5/adt, which is equivalent to $1.4 m pa at the 800 adtpd level.

4.4.2 Sensitivity Analysis

It is unclear from the prefeasibility study as to whether the capacity of the three overseas mills could be increased to 800 adtpd. (This aspect is touched on in Section 5.1.1 of this Reed study). If not, then this sensitivity is academic.

Further, the effect of a $50/adt price increase on the internal rate of return is not strictly comparable between the Korean mill and the overseas mills, because they are caused by different circumstances (page 119). To put them on a comparable basis, the circumstances that give a $50/adt increase in c and f price to the three overseas mills would give a $62.66/adt improvement to the Korean mill. This results from the various mark-up elements detailed on page 113. The Korean mill would thus benefit by $12.66/adt more than is shown in the study. This is equivalent to $2.66 m pa at the 600 adtpd level. It would bring the Korean mill's internal rate of return close to that of the Australian and Californian mills.

The same consideration applies to the estimate of the effect of a $100/adt price increase on gross ROI (page 117), except that the difference is now twice as large.

4.4.3 Korean Pre-Production Costs

Reed was requested to give its opinion on the pre-operating and start-up costs allowed for the Korean mill (page 107). These costs are $0.6 m and $1.2 m higher, respectively, than those for the overseas mills.

In the case of the pre-operating costs, the additional cost is that of the training programme. The programme would essentially be conducted at the existing Donghae mill, and the main cost will therefore be that of employing the trainees prior to start-up. Page 95 shows the annual pay bill for all the additional manpower required as $1.0 m pa. The training programme (Appendix 1) states that all 175 of the new employees would be trained, with the bulk being recruited nine months before start-up. Were this to be done, it would involve a $0.75 m pay bill. In practice, some of the new employees (eg: lesser skilled, some tradesmen, secretaries, etc) would be trained for shorter periods, so that a total cost allowance of $0.6 m for the training programme seems reasonable.

As for the $1.1 m extra for start-up costs, this figure alone could be justified on the basis of the expatriates required by the contractor to meet the performance guarantees. Sometimes material consumptions above standard usage are included under this heading, but they have been allowed for in the computation of "operating costs" in the first two years.

4.5 SUMMARY OF MODIFICATIONS

How do the above cost modifications change the picture presented in the study? No major modifications have been made in the costs of the California or British Columbia mills, so they remain essentially unchanged. The other main changes can be summarised as follows.

	Korea	Australia
Sales Revenue - 800 tpd		+$5/adt
Fuel Oil Cost - 600 tpd	-$8/adt	
Capital Cost - 600 tpd		-$17.9 m
Interest Rate - local	-2.0%	
- foreign	-1.5%	
Debt Interest (Year 4) - 600 tpd	-$13.8/adt	
- 800 tpd	-$11.8/adt	
Construction Interest - 600 tpd	-$11.7/adt	
- 800 tpd	-$8.9/adt	

Evidentally the $33/adt reduction in cost at 600 adtpd (or $31/adt at 800 adtpd) for the Korean mill is insufficient to bring the project into the viable range.

Taking into account the modified costs for the Australian mill, the comparison of gross return-on-investment between the three overseas mills now becomes.

	Australia	California	British Columbia
Base Case (210,000 adtpy):			
Gross Profit ($'000 pa)	30,349	21,407	30,503
Gross ROI (%)	13.8	12.0	15.6
Capacity of 280,000 adtpy:			
Gross Profit ($'000 pa)	43,207	31,558	43,549
Gross ROI (%)	16.8	15.2	18.9

Thus the return on the Australian mill is now close to that of the British Columbia mill. In fact the wood price of the BC mill is somewhat theoretical, and it would only take a 14% increase in wood price over that used in the study to bring the ROI of the BC mill down to that of the Australian mill. Nevertheless the ROI of both mills is still below an acceptable level.

4.6 SUBJECTS WARRANTING FURTHER STUDY

While studying the question of a Donghae mill expansion, we have been struck by a number of topics that justify further study. Some will help a future expansion of the mill and some the existing operation. We will now list these topics.

a) Turpentine. At present the mill burns its turpentine, whereas it might be more profitable to sell it to Japan. They import crude turpentine from North America, so there is a freight advantage. Alternatively, there could be facilities in Korea that could use it more profitably. The price of refined turpentine in Korea is $345 per drum (180 kg) exclusive of VAT.

b) Harbour. Two different scales should be considered. A simple barge dock would permit wood and other materials to be brought in by sea, with pulp possibly going out on the back-haul. A dock capable of accepting chip vessels would be more expensive and might only be used at times in the economic cycle when chips became available.

c) Hog Fuel. At present, waste wood from the wood room is sold as fuel. If the price received by the mill is not close to its fuel equivalent price, then it could be more profitable to burn it at the mill. Failing that, the boiler for the expansion could be sized to burn the waste wood available from both mills.

d) Chloralkali. Any expansion should consider generating chloralkali on site for the total mill plus any local users. This would permit the mill to control its chloralkali costs to a greater extent than exists at present.

CHAPTER 5 - REVIEW OF PREFEASIBILITY STUDY CONCLUSIONS

Bearing in mind the strategic background and the modifications suggested for the mills, we will now examine the options evaluated by the prefeasibility study and the corresponding conclusions.

5.1 OVERSEAS OPTIONS

5.1.1 Option B

This option evaluated the economics of hypothetical mills in Australia, California and British Columbia. For each location, the basic case (corresponding to a 600 adtpd UKP mill) was found to be financially unattractive. However, an increase in selling price of $50/adt in combination with an increase in mill scale to 800 adtpd, moved the projects close to the viable range. These findings are in line with our expectations and we will now provide the reasoning.

Figure 1 in Appendix I provides a starting point. In essence it summarizes the range of mill scale that is 'viable' according to the relevant market, finished product and fibrous raw material utilised. Each range of mill scale is represented by full lines for the most commonly encountered local circumstances and by broken lines for those less commonly encountered.

Since the three mills under consideration are producing export pulp from wood, we are looking at the uppermost range in Figure 1. It shows that the most commonly encountered range of viable mills is 240,000-325,000 adtpy. The smallest viable scale is usually around 200,000 adtpy. The smallest viable scale is usually around 200,000 adtpy, but certain unusual compensating economic factors are necessary to justify this extreme.

The "base case" evaluated by Simons was 210,000 adtpy. It will be seen that this scale falls at the lower end of the broken line - thus indicating that some special economic factor, that compensated for the smaller scale, would have to be present for the project to be viable. In the present case there are no such special factors.

Moreover, Figure 1 refers to mill producing bleached pulp, while the study refers to unbleached pulp. The production of unbleached pulp is less profitable than that of bleached pulp. This results from the world price

of unbleached pulp being held down by the availability of kraft linerboard from the southern US mills. For a part of the economic cycle, these mills have capacity in excess of US domestic needs. The balance is exported and can be repulped (as UKP) if the price of market UKP rises much above that of kraft linerboard. The linerboard is sometimes perforated, so as to qualify as pulp for duty purposes. These southern US mills have the advantage of cheap wood and are able to undercut most of the world's pulp mills in other regions.

Curves 1 and 2 in Figure 2 of Appendix I show the difference in financial return of unbleached and bleached kraft mills. When the prefeasibility study was carried out (in January 1980) the difference in price (cif Korean port basis) between unbleached and bleached kraft pulp was about $97/adt. This price difference exceeds the difference in manufacturing cost, thus providing a higher profit.

Given these distinctions, the 210,000 adtpy unbleached pulp mills now fall below the viable scale in Figure 1.

The prefeasibility study found that the combination of a $50/adt increase in selling price and an increase in scale to 280,000 adtpy moved the three projects close to the viable range. The $50/adt increase in selling price corresponds very roughly to the improvement in profit from producing bleached rather than unbleached pulp over the economic cycle. Figure 1 is applicable to bleached mills and a bleached mill of 280,000 adtpy would normally be viable. On this basis, the prefeasibility study's conclusion is in approximate agreement with Figure 1. Incidentally, it will be recalled, from Chapter 3, that all the Japanese overseas mills have bleach plants.

Four, out of the six, existing overseas Japanese pulp mills also had associated lumber operations. This is obviously an advantage in that it provides a proportion of relatively inexpensive chips in the raw material furnish. Incidentally, we note that the prefeasibility study (page 3) cites the UNIDO Terms of Reference for this option as including "integrated timber production".

Summarising the above, we believe an overseas mill would be viable if:

a) It had bleaching facilities and the bulk of its production was bleached, rather than unbleached, export pulp.

b) Its scale was a minimum of 280,000 adtpy (ie: 800 adtpd) and preferably larger.

c) The availability and price of the bulk of its wood was under the mill's control. An associated captive lumber operation would be one means of achieving this.

Negotiating the capital equipment contracts during a recessional period would also help to improve the economics.

Item (a) above should not render this formula unacceptable, even though the object of the prefeasibility study was to secure Korea's UKP supply. Such a mill's profitability is dependent upon its producing bleached pulp. The production of UKP would be most acceptable to the mill when its selling price was not depressed by excess linerboard capacity, (corresponding to UKP being expensive, and possibly scarce, in Korea) or the mill was short of orders for bleached grades. At other times, bleached softwood (or hardwood) pulp would be taken to meet some of the ROK's requirements.

How suitable are the three overseas locations, evaluated by the prefeasibility study, for a mill that is in line with the above three-point formula? The answer is not totally clear from the study, since it did not set out to evaluate this concept. However we can make the following observations.

a) Australia. This is the firmest of the alternatives, although there are some indications that APM is prepared to go ahead without a partner. At present they are conducting a feasibility study. They will probably build a bleached pulp mill, but with a capacity of 150,000-200,000 tpy. APM admit this to be "relatively small" by international standards and its viability remains to be determined. Presumably wood availability, and possibly high effluent disposal costs, preclude a larger mill. About half the wood source is owned by APM and a part of the remainder comes from State forests. It is believed that a captive lumber operation is not involved.

b) California. This site appears suitable for a bleached pulp mill, but the availability of wood sounds too tight for a mill larger than 600 adtpd. Moreover, most of the wood is bought in by NCEC, and the price and availability is therefore not under their control. Being a chip operation, no associated captive lumber operation would be involved. At first sight, there would seem to be more mutual

interest in NCEC making possible the expansion of one of the two neighbouring BKP mills (currently 590 and 600 tpd) - rather than creating a new separate 600 adtpd mill.

c) British Columbia. This is also a tight geographical region for wood availability, particularly when off-shore (ie: Japanese) demand is high. Thus wood is the principle question mark here. Indeed it could be one reason for the closure of the present Ocean Falls mill. The status of this potential site as a prospect depends mainly on what concessions the Forest Ministry is prepared to give regarding long-term wood allocation - and the associated cost of that wood. It sounds as if there is potential for captive sawmill(s), capable of providing 25% of the mill's wood supply, but the availability of sufficient wood for an 800 adtpd mill is unclear.

In Chapter 4 we saw that, once the modifications derived in that chapter had been taken into account, the Australian and BC mills showed similar returns on investment. The Australian project is the more definite of the two and the mill's superior control of its wood price is a particular attraction. We have shown earlier in this chapter that a bleached version of a mill should be more profitable than the unbleached version. However, whether the Australian mill can be viable at only 150,000-200,000 adtpy of bleached pulp remains to be determined.

It is of interest to note that the Australian federal government has recently undertaken a study jointly with Japan that has identified eight potential sites for new pulp mills. Four are based on using softwood and four on hardwood. Plantations in New Zealand are also getting to the point where they will sustain a viable scale mill. Other countries, possibly with a higher associated risk, with wood resources that are looking for investers are Chile, Guatamala, Peru and Indonesia.

Thus there is no shortage of potential locations open to the ROK. The real question is the terms to which the local partners and government would agree. To the extent that the local partners 'played the market', the Japanese are likely to outbid the ROK. Thus, as we predicted in the context of obtaining overseas wood sources, there is the possibility that the ROK would be left with a choice between the least advantageous locations for a pulp mill. To illustrate the point, one could say that there are three or four marginal or poor potential pulp mill sites for every good one.

The main contribution of a foreign partner, besides providing equity capital, is to ensure a steady and high offtake when the pulp market is weak. Given Japan's large import pulp requirement, it would be able to equal any ROK proposal in this respect.

What would be the likely cost of taking a majority equity holding in such a mill, so as to have better control over some aspects of the operation? Were the Korean partners to take a majority holding (assuming they were allowed to do so), they would be unlikely to find other local partners that would permit them to hold only 51%. More likely, they would have to take at least 65% before they would find partners willing to provide the balance of the equity. A stake of 65% in the equity of an 800 adtpd BKP mill, integrated with lumber production, would require an investment of around $60 m (at May 1980 prices).

5.1.2 Option C

This option involved the acquisition of a suitable existing overseas integrated "timber" (presumably lumber rather than straight wood) and pulp mill operation. In the event, it proved impossible to find such a mill, so the option was not evaluated.

It is not surprising that a suitable mill could not be found at the time. Indeed, any mill that was up for sale when the world market pulp market was so healthy, was unlikely to be a sound investment.

If a potentially suitable mill did come on the market, it would be near the bottom of the economic cycle. The major economies are now entering a recessionary period, although there are conflicting opinions as to how severe and long the recession will be. Most pulp mills will be able to survive a short shallow recession, but one similar to that in 1975 would provide opportunities for an acquisition.

In assessing any potential acquisitions, particular attention should be paid to the points made above - namely, control of wood supply and price, scale, bleaching capability and equity stake. In fact, wood prices and availability that are beyond the mill's control, are one of the main reasons for pulp mills being sold off. The other main reason is the requirement for large sums of capital to replace old equipment, and also to install modern air and water pollution control facilities.

5.2 KOREAN OPTION

Option A involved expansion of the existing Donghae mill by 600 adtpd using imported wood chips, procured from overseas on long-term contracts, as the fibrous raw material.

The resulting financial return proved the poorest of the four alternatives evaluated. In fact a much greater potential error is associated with this evaluation than is the case with the other three alternatives. We will now explain this viewpoint.

The method employed in the prefeasibility study, of taking actual selling prices and costs at a given point in time, is internationally recognised. Nevertheless, the method does depend upon there being a fair equilibrium between selling prices and costs at the time chosen. This financial state of equilibrium did not exist in January 1980, because the world was experiencing the characteristically volatile peak of an economic cycle. Thus, during that month in Korea, the Korean Won was devalued by 20% (and allowed to float), oil prices were increased by 59%, chip prices by 66%* and interest rates by about 25%. By contrast, the price of pulp only increased by 8% over the previous month. Yet by May 1980, UKP prices for Korea were up by 30% over December 1979.

One is therefore left wondering as to what extent the costs used in the study reflect the true profitability of the mill. One is not able to tell whether prices were lagging and costs were leading, or vice-versa. To give a numerical illustration of the potential error, had the oil price increase occurred three days later, so as to fall in February, the gross profit of the 600 adtpd Korean mill would have been £4.75 m pa higher, and the gross ROI would have come out at 15.4% instead of 12.8%.

*Note that the prefeasibility study figure (page 80) of 21% refers to the increase over the price initially announced for January 1980, while 66% refers to the increase over that actually prevailing in December 1979.

In order to clarify this area of doubt, we have attempted to reconstruct the position in mid-1977 and in December 1979. Mid-1977 represents a point in time when both pulp and energy prices had been fairly steady for some time, and relatively depressed economic conditions existed. Thus prices and costs should have been in fair equilibrium, albeit at a low level of profitability. December 1979 has been chosen because, although pulp prices had risen considerably since mid-1977, the large wood price increase had not yet been implemented. Thus the mill would be expected to be at about its most profitable at that time.

The financial reconstruction is shown in Exhibit 5.1. It incorporates the fuel oil cost modification derived in Section 4.1.3. Moreover it assumes international oil prices in mid-1977. Fuel oil was subsidised in Korea at that time, but the subsidy had essentially disappeared by January 1980. For costs other than wood and fuel oil, an inflation factor of 25% (in US dollar terms) has been assumed between the two periods.

Exhibit 5.1 shows that the gross ROI in mid-1977 was only 1.0%. Moreover this condition would probably have prevailed for about 15 months. The mill would have been at its most profitable in December 1979 - that is, before the large wood price increase and further fuel price rise were implemented. At that time it would have shown a gross ROI of about 18%. Taking 1% and 18% as the minimum and maximum ROI, respectively, the average ROI over the whole of the economic cycle would have been around 8%. Thus the prefeasibility study gives a rather optimistic picture of the overall economics.

Parenthetically, the same is probably true for the three overseas mills. Applying an appropriate negative sensitivity, in the form of a selling price reduction, would have given a more accurate picture of the overall economics for all four mills. However the evaluation of the actual return in January 1980 should be more accurate for the overseas mills, since the relevant price changes were more gradual.

It is evident from the above, that a Korean mill based on imported wood is even more unviable than the study shows. This is in line with our previous reasoning. It is also in line with Figure 1 of Appendix 1. There we saw

EXHIBIT 5.1 - ESTIMATE OF GROSS RETURN AT 600 ADTPD KOREAN MILL IN MID-1977

	Mid-1977	January 1980
Wood Cost ($/adt)	177	268
Fuel Oil Cost ($/adt)	25	52
Other Variable Costs ($/adt)	29	37
Total Variable Costs ($/adt)	231	357
Total Fixed Costs ($/adt)	16	21
Sub-Total ($/adt)	247	378
Net Sales Revenue ($/adt)	254	497
Gross Profit - $/adt	7	119
- $ m pa	1,470	24,990
Total Investment ($ m)	146	183
Gross ROI (%)	1.0	13.7

that a (bleached) mill would require some compensating economic advantage to make it viable at the 210,000 adtpy level. In fact the Korean mill has a very distinct economic disadvantage in that it has no control over its wood cost.

CHAPTER 6 - KOREAN MILL BASED ON DOMESTIC WOOD

6.1 NON-CAPTIVE WOOD BASIS

We concluded in the last chapter that a Korean mill based on imported wood would be even more unviable than is shown in the prefeasibility study. The next question to ask is: "Would a Korean mill be viable if sufficient domestic wood were available?".

Exhibit 6.1 shows the long term supply/demand projection according to the current 10-Year Forest Development Plan, which runs from 1979 to 1988. The projection does not include fuel wood, in which Korea is essentially self-sufficient. The values for 1980 are the latest estimate rather than the projection contained in the Plan. In fact the latest estimate for 1980 is for a total demand about 1% higher than the Plan figure, but with wood for domestic use up by about 5% and wood for export use down by a similar amount.

On the demand side, "general use" refers to wood for other purposes, such as housing and furniture. "Export use" means the manufacture of wood products that are subsequently exported. In 1980 this was expected to be 73% for plywood and 27% for sawn timber.

On the supply side, the "imported timber" figures include wood waste from Korean plywood plants and sawmills that utilise imported wood. In 1980, this is expected to amount to about 987,000 cu m. The word "exploitation" refers to the Korean forestry concessions overseas, which are mainly in Indonesia.

It will be seen from the exhibit that 48% self-sufficiency is aimed for by the year 2030. Thus there will be an on-going deficit situation for the essential lifetime of any pulp mill. In such situations, the price of wood purchased in a free market tends to be similar to that of the alternative supply - namely imported wood. Korea is no exception to this generalisation, since free market conditions exist for the purchase of wood. Thus the economics of a domestic mill based on domestic wood are similar to those of a mill based on imported wood. In both cases the price of wood equals or is close to that of imported wood, and neither mill has any control over its fibrous raw material cost.

EXHIBIT 6.1 - LONG TERM SUPPLY/DEMAND PROJECTION FOR WOOD

(in '000 cu m)

	1978	1980	1988	1990	2000	2010	2020	2030
Demand:								
Domestic Use:								
Pit Props	617	600	718	670	-	-	-	-
Pulpwood	203	833	1,630	2,074	-	-	-	-
Veneer Logs	1,603	2,376	4,528	4,729	-	-	-	-
General Use	3,688	4,204	6,315	7,068	-	-	-	-
	6,111	8,013	13,191	14,541	19,542	22,679	24,560	25,600
Export Use	4,473	4,384	4,794	4,794	3,000	2,500	2,000	1,500
Total	10,584	12,397	17,985	19,335	22,542	25,179	26,560	27,100
Supply:								
Domestic Timber:								
General Species	1,200	1,160	1,400	1,500	2,000	4,000	6,000	8,000
Poplar Species	70	117	889	1,450	4,416	5,000	5,000	5,000
	1,270	1,277	2,289	2,950	6,416	9,000	11,000	13,000
Imported Timber:								
Purchased	8,714	9,245	14,746	15,385	-	-	-	-
Exploitation	600	888	950	1,000	-	-	-	-
	9,314	10,133	15,696	16,385	16,126	16,179	15,560	14,100
Total	10,584	12,397	17,985	19,335	22,542	25,179	26,560	27,100
Self-Sufficiency (%)	12	11	13	15	28	36	41	48

In Chapter 3 we noted that some Japanese pulp companies control significant quantities of woodland. The price of this part of their raw material is thus under their control. Therein lies the strategy for the expansion of Donghae. Namely, Donghae should establish, as close to the mill as possible, captive plantations that will supply it with a significant proportion of its future raw material.

6.2 CAPTIVE WOOD BASIS

Obviously the whole question of establishing such a wood resource requires detailed study. However we will attempt to provide some indication of the nature of the resource and its associated economics. Naturally any values used at this stage can only be regarded as very approximate.

6.2.1 Location of Wood Resource

In 1978, two-thirds of the total Republic of Korea land area was forest. The bulk of this was private forest (72%), while national forest accounted for 20%, public forest for 8% and the remaining 8% was unsurveyed.

The distribution of total growing stock (114,000,000 cu m) was 50% in private forests, 43% in national forests and 7% in public forests. It is worth noting that in 1972, the total growing stock was only 72,696,000 cu m, although the forest area was almost identical. The breakdown of the total growing stock by age class in 1978 was as follows (in m cu m).

	Softwood	Hardwood	Mixed
1-10 years	4.1	1.2	2.6
11-20 years	26.2	7.9	13.1
21-30 years	6.1	12.9	9.2
31-50 years	5.7	9.6	7.9
>50 years	1.1	4.5	2.1
	43.2	36.0	34.8

The privately-owned forests are organised on a provincial basis. The national forests are sub-divided into three National Forest Stations (NFS). Exhibit 6.2 shows the boundaries of the provinces ("do" in Korean). The boundary between the Eastern NFS and Central NFS runs approximately down the watershed of the Taebaeg mountain range until it reaches the boundary between Gangweon province

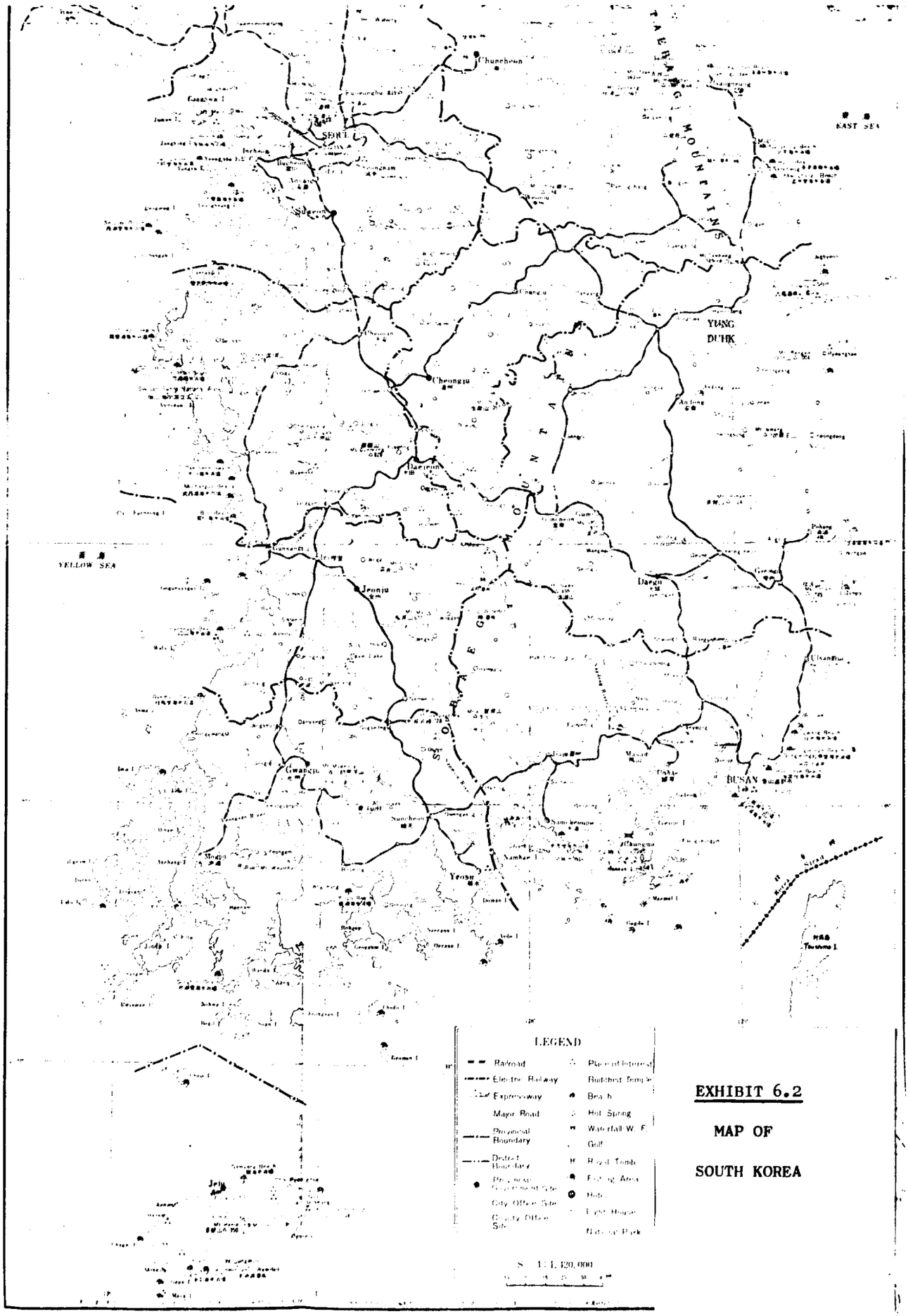

EXHIBIT 6.2

MAP OF

SOUTH KOREA

and Geongbug province, which it then follows eastwards until the sea. The boundary between the Southern NFS and Central NFS follows approximately the watershed of the Sobaeg mountain range. Thus the Southern NFS corresponds approximately to the two provinces of Geongbug and Geongnam.

By grouping these areas, we can thus derive the geographical distribution (in 1977) shown in Exhibit 6.3. In the present context, the "Southern Region" is of most interest, because of its proximity to the Donghae mill. It will be seen that this region contains about 35% of total ROK forest area. In both provinces, about two-thirds of the total land area is forest. About 59% of the total growing stock is in private forests, but this is much less densely stocked (at 9.1 cu m/ha) than is the NFS forest area (46.7 cu m/ha). This is particularly true of Geongnam province, where the density of stocking is only 6.4 cu m/ha.

The ROK has four groundwood mills, with the following capacities and locations.

Mill	Location	Capacity (tpy)
Daehan Paper Mfrg	Seoul	20,000
Sampoong Paper Mfrg	Seoul	17,000
Sedae Paper Mfrg	Gunsan	37,000
Chonju Paper Mfrg	Jeonju	80,000

Thus the geographical distribution of these mills is fairly neat. Donghae can develop the wood resources of its two local provinces, leaving the north clear for the two Seoul mills and the west free for the two Jeonbug province mills.

Donghae has in fact already studied the more intensive afforestation of the Yung Duhk region, which is located in the north of Geongbug province. Of the 34,695 ha that can be cultivated, 19,691 ha could be clear-cut and replanted, while most of the rest would be allowed to continue to grow. The clear-cutting programme would provide an annual average of 51,000 cu m of softwood pulpwood (mainly pinus densiflora and pinus ligida) and 37,400 cu m of hardwood pulpwood (mainly oak). This pulpwood is in the 6-30 cm dia range. Some larger trees would also be available for sawlogs.

This clear-cutting is scheduled over 15 years. At the end of that time, the plantation softwood will yield 150 cu m/ha and the hardwood will yield 130 cu m/ha. Thus, by clear-cutting 1,637 ha annually, a sustainable yield

EXHIBIT 6.3 - GEOGRAPHICAL DISTRIBUTION OF FORESTS IN 1977

	Area ('000 ha)		Growing Stock ('000 cu m)		Average Growing Stock Per Unit Area (cu m/ha)
	Private Forest	National Forest	Private Forest	National Forest	
Southern Region:					
Southern NFS	-	220	-	10,272	46.7
Geongbug Do	1,198	74	12,934	1,820	11.6
Geongnam Do	768	44	4,930	329	6.5
Total Southern	1,966	338	17,864	12,421	13.1
Eastern and Central Regions:					
Eastern NFS	-	279	-	12,650	45.3
Gangweon Do	717	38	13,323	610	18.5
Sub-Total	717	317	13,323	13,260	25.7
Central NFS	-	366	-	15,435	42.2
Seoul	12	6	256	114	20.6
Gyeonggi Do	529	53	5,997	649	11.4
Chungnam Do	461	28	6,183	473	13.6
Chungby Do	447	65	7,148	2,126	18.1
Jeonbug Do	396	44	4,026	447	10.2
Jeonnam Do	672	61	7,533	654	11.2
Jeju Do	78	29	1,472	1,630	29.0
Sub-Total	2,595	652	32,615	21,528	16.7
Total	3,312	969	45,938	34,788	18.9
Grand Total	5,278	1,307	63,802	47,209	16.9

of 227,550 cu m pa will be obtained. No information was available regarding the delivered price of this wood.

It would appear that a similar approach could be taken to other areas of Geongbug and Geongnam provinces. In this way there could be a multifold increase in the density of stocking, while the existing Donghae mill received both softwoods and hardwoods for pulping. Certainly the nearer the new plantations are to the mill, the better should be the delivered price. When studying such future plantations, consideration must be given to the infestation of pine needle gall midge that is affecting about 300,000 ha to the north and east of Ulsan.

6.2.2 Delivered Price of Wood

The prefeasibility study stated that an expansion would be viable if wood could be obtained at a delivered price of $35/cu m. The H.A. Simons wood study (page 125), undertaken in the last quarter of 1974, gave estimated costs of softwoods and hardwoods delivered to Onsan from Gangweon province. This is a rugged mountainous area about 400 km from the mill. The costing was based on the labour-intensive harvesting methods then used in Korea. Thus the delivered cost should be significantly higher than that from local plantations.

To update this estimate we have used the change in wholesale price index over the period. The factor is 2.15 (on a Won basis), which gives a value of $35/cu m for pine and $32/cu m for oak. Even though these figures are only approximate, it is evident that the greater productivity and lower infrastructural costs possible with plantations plus the shorter haul to the mill, could make wood available at under $35/cu m. In fact, based on experience with plantations elsewhere, a delivered price of around $25/cu m should be achievable.

6.2.3 Area of New Plantations Required

The area of new plantation required will essentially be that necessary to secure the required wood price for viability. Say, for example, as in the prefeasibility study, that the price of imported wood is $56/cu m and the maximum wood price for viability is $35/cu m. The price of domestic wood purchased on the free market will approximate to that of imported wood. If a captive plantation price of $25/cu m can be achieved, then a mix of 67% captive wood and 33% domestic/imported wood will give an overall price of $35/cu m. The existing Donghae mill also has to be considered. Given its smaller scale, the ratio is now probably more like 80% captive wood to

20% domestic/imported wood. Thus, assuming an expansion of 600 adtpd, we are looking for sufficient wood to support a total output of 640 adtpd.

While the objective of the prefeasibility study was to secure a supply of softwood UKP, it is evident that hardwoods grow more rapidly than softwoods. Thus an expansion of Donghae would be achieved more rapidly from hardwood plantations than from softwood plantations. On the basis of the projected 1983 consumption figures alone, Korean paper mills will be able to absorb 900 adtpd (315,000 adtpy) of bleached hardwood pulp. In practice, a proportion of the output of the pulp mill will be softwood pulp. Donghae has already produced some softwood UKP. Ssangyong could evaluate its suitability for its requirements.

The hardwood species planted is likely to be poplar. The species populis alba is one of the fastest growing of the local poplars, but (according to pulping tests published in Korean Tappi Vol 3, No 2, 1971) it gives a rather weak pulp. These results refer to the unbleached pulp. The suitability of the bleached grades for Korean paper mills' requirements would have to be determined. If suitable, according to yield tables showing average conditions for plantations in Korea, sufficient wood to sustain 640 adtpd of production could be obtained from a total of 80,000 ha using a 12-year rotation.

Alternatively, were poplar species giving a stronger pulp required, the wood yield (115 versus 185 cu m per ha) and wood density (0.30 versus 0.36) would be lower and the rotation time now 15 years. This would require a total area of about 210,000 ha. These areas are fairly modest relative to the areas under forest in Geongbug and Geongnam province (see Exhibit 6.3).

Donghae should also plan for some long rotation species. These softwoods should be allowed to grow to sawmill size, and the pulp mill would use the sawmill residues and forest thinnings. A rotation of about 30 years is indicated.

Obviously much of the above needs to be defined further. For example, a small decrease in rotation time would give a useful decrease in the land area under plantation and thus in the investment required.

6.2.4 Investment Cost and Financial Return

The publication containing the synopsis of the Second 10-Year Forest Development Plan contains (page 57) some values for the investment that plantations involve. Updated to May 1980, the values become.

Species	Rotation (yrs)	Investment ($ per ha)		
		Establishment	Tending	Total
Poplar	15	461	364	825
White Pine	40	630	630	1,260

On the basis of these figures, the 80,000 ha required for a 12-year rotation of populis alba would require an investment for establishment of $37 m followed by a total of $29 m (at May 1980 prices) for tending during subsequent years. This total of $66 m compares with the $60 m it was estimated would be needed to acquire the minimum practical majority stake (65%) in an overseas 800 adtpd BKP mill.

Were populis alba pulp to prove unsuitable for the Korean paper mills' needs and a stronger pulp was required, the investment cost would be higher. Thus for the 210,000 ha required for a 15-year rotation of other poplar species, the cost would be $97 m for establishment followed by a total of $76 m for tending.

In addition there would be the cost of establishing and tending the long rotation softwood species for sawmill production.

The same publication also indicates the kind of financial return that can be expected. For poplar, the total investment (which occurs mainly in the initial years) is multiplied by a factor of 10 over 15 years (ie: 16.7% pa compounded). For white pine, the total investment is multiplied by a factor of 14.4 over a period of 40 years (ie: 6.9% pa compounded). Since this is at constant prices and wood prices usually stay abreast of other prices, these are real returns (ie: over-and-above inflation). However the selling prices used in the publication are evidentally based on selling wood in a free market. In the present context, the return would depend on the actual price at which the wood was transferred to the pulp mill.

CHAPTER 7 - CONCLUSIONS AND RECOMMENDATIONS

In this study we have established that an overseas BKP mill, of capacity not less than 800 adtpd, could be a viable proposition. The mill must also have control over the bulk of its wood supply and price. Although there are several potential sites for such mills, the best sites are likely to be hotly contested by the Japanese. The possibility is that the ROK could be left with a choice between the least advantageous sites.

Of the three overseas sites evaluated, question marks exist regarding all three as to their suitability for a viable 800 adtpd BKP mill. The Australian mill is the firmest alternative, but it has the double disadvantage of evidentally not being larger than 200,000 adtpd and a high capital cost. Both factors lead to a high capital cost per ton of output. The main disadvantage of the North American alternatives is that the wood cost appears not to be under the mill's control.

Nevertheless it is recommended that the ROK keep abreast of these and other overseas projects, to the extent that this can be done without incurring heavy expense. In the event of there turning up a project with potential, according to the guidelines given in this study, they may wish to take expert advice. It is estimated that the minimum practical majority equity stake (65%) in an 800 adtpd BKP mill would cost about $60 m. A minority stake would cost correspondingly less.

The present Reed study has concluded that the Korean mill, based on imported wood, has even poorer economics than are indicated in the prefeasibility study. Further, that the economics of a mill based on domestic Korean wood purchased on the free market would be similarly poor, since the price of this wood is similar to that of imported wood. In both cases, the mill has no control over its raw material cost.

The remaining alternative is a mill based on a part-captive wood supply. Unless an attractive overseas investment becomes available to the ROK, which seems unlikely, the development of captive plantations would be the soundest route to pursue.

Probably the most rapid way to establish such plantations would be to plant populis alba, or some other very fast growing species, for harvesting in the

first four years. This assumes that the species' pulp is acceptable to the Korean paper mills. For the harvest in subsequent years, poplars giving a stronger pulp would be planted. In this way, a pulp mill could start up about 11 years after commencement of the planting programme. If the programme starts in 1981, construction of the expansion could commence in 1989.

Since the mill will be processing hardwoods, it will need bleaching facilities. The feasibility study should determine whether the production of dissolving pulp is justified. The existing Donghae mill and the expansion will also produce both UKP and BKP from domestic and imported softwoods. The domestic softwood will be made available by the clear-cutting programme, as well as from existing domestic sources. Subsequently they would be available from forest thinnings and sawmill residues. Imports of softwood chips may be feasible during periods of low demand by the Japanese.

Thus the first priority is for an in-depth study of the creation of captive plantations in the Donghae region. In addition, Donghae should study the items mentioned in Section 4.6 that might improve its operation.

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Optimum is beautiful: small mills can work

There can be a place for small mills, even in the industrialized countries, provided they are making the right grades from the right raw materials on the right equipment and in the right place. A look at the economics of the small mill—and slightly larger one—by PPI's UK editor Roger Grant.

The sentiment "small is beautiful" has received little more than polite interest from our industry. Small wonder. Juggernaut mills make spectacular reading, and their creation and operation provide work for many suppliers and engineers. For the eventual mill owner, large scale appears to be a built-in means of counteracting unfavorable economic influences.

Few things can be extrapolated indefinitely. Since costs took off at the end of the 1960s, a small but growing school has been questioning the wisdom of increasing scale, in the context of both developed and developing countries. The recent saturation of certain markets has focused additional attention on the subject. Other industries have similarly been studying their own operations.

Little has been published of an economic nature on the question of scale, and this article attempts to help fill the gap. It is, of course, necessary to make numerous generalizations; this should not cloud the fact that every mill has its own individual economics.

By way of clarification, the article refers primarily to the optimum initial capacity of a new greenfield site mill. However, expansions are a recognized means of improving a mill's economics, and the principles discussed here generally apply. Further, we need to explain three terms that appear frequently in the text:

- "Capital burden" is used to denote the sum of interest and depreciation.
- "Unit," as used in "unit power cost," etc., refers to the cost of power per ton of mill output. Mill output can be regarded as synonymous with mill capacity for the present purpose.
- "Optimum." The optimum scale of mill is the most acceptable mill size when all influencing factors have been taken into consideration. As we shall see, it is not necessarily the scale giving the maximum financial return.

Figure 1 permits us to take a broad initial view of the subject. In essence it summarizes the range of mill scale that is "viable" according to the relevant market, finished product and fibrous raw materials available. Each range of mill scale is represented by full lines for the most commonly encountered local circumstances and by broken lines for those less commonly encountered.

Wheat straw and esparto grass mills usually fall into the lower part of the "bagasse" range. Mills producing paper for export are usually integrated with pulp mills of capacity similar to the range shown for export pulp. Their slush pulp is generally either totally converted into a single family of grades (mechanicals or linerboards) or else fragmented between a limited number of products (writings and printings, coateds and market pulp). This does not apply to paper specialties, which can of course be produced competitively in smaller scale mills.

Two factors stand out as influencing the mill scale range. One is the protection that import duties can provide in the domestic market, but not in the international (export) market. The other is the total cost of pulping as related to the selling price of the finished paper product. To illustrate the latter, rice straw is generally cheaper than wood and requires less expensive processing to produce papers of similar acceptability to the market of a developing country.

Figure 1 in fact shows the mill scale ranges within which acceptable financial returns are produced. Let us now look more closely at the elements that influence this

Résumé—Les petites enterprises peuvent être rentables dans le monde industrialisé à condition d'être situées au bon endroit, de produire les qualités de papier requises et d'employer la technologie appropriée. Elles peuvent également trouver leur place soit à l'extérieur des pays en voie de développement qu'à l'intérieur de ces pays.

Zusammenfassung—Kleinere Fabriken können in der industriellen Welt auch einträglich sein, unter der Bedingung, dass sie am richtigen Ort stehen, die richtigen Papiersorten herstellen und die richtige Technologie anwenden. Sicher gibt es für sie einen Platz, sei es ausserhalb wie auch innerhalb der Entwicklungsländer.

Sumario—Fábricas pequeñas pueden set gananciosas en el mundo de la industria, a condicion de sèr bien situada, de producir las buenas clases de papel y de emplear la buena technologia. Hay seguramente un sitio para ellas al exterior de los paises de desarrollo y tambien en el interior.

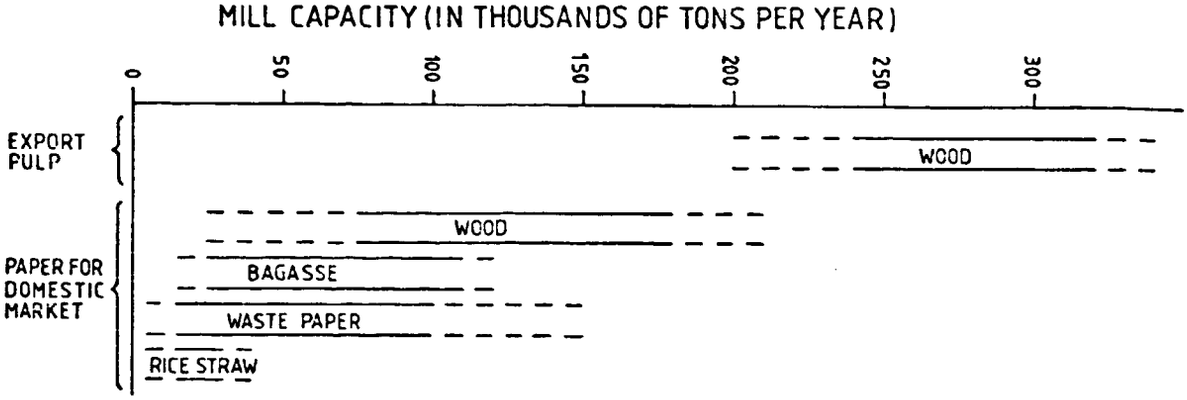


Figure 1: Viable levels of mill capacity according to market, finished product, and fibrous raw materials.

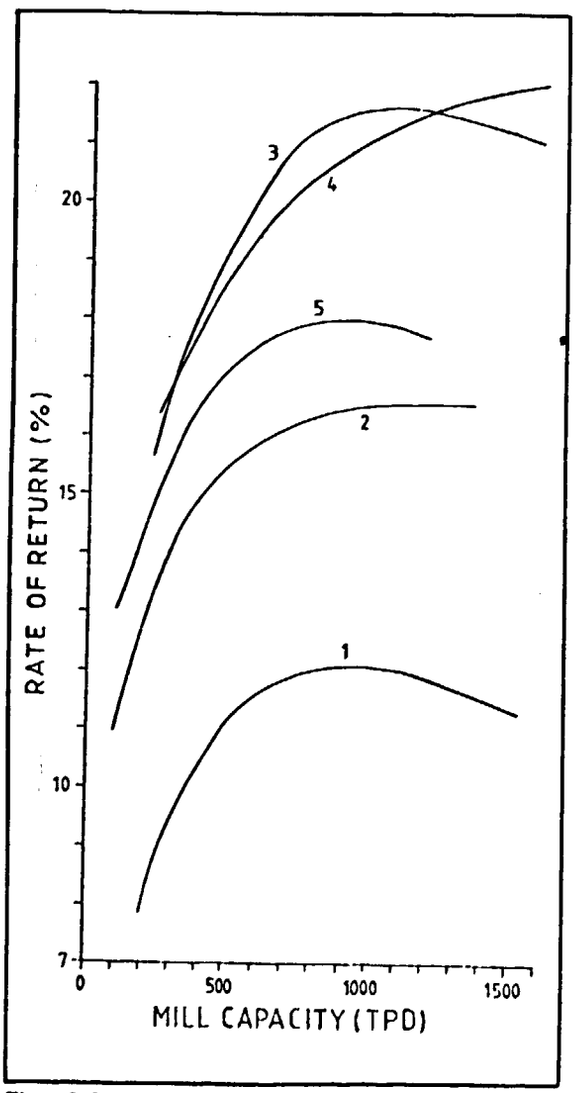


Figure 2: Influence of mill scale on the rate of return for mills making: 1. unbleached kraft pulp from pine; 2. bleached kraft pulp from pine and birch; 3. unbleached Mg sulfite pulp from spruce; 4. newsprint from spruce pulpwood and purchased unbleached sulfite; 5. corrugating medium from birch pulpwood and purchased kraft pulp.

return. In round terms we can classify them as being of three types, according to how their unit cost varies with mill scale.

The unit costs of two elements, namely capital burden and salaries, decrease fairly markedly with increasing mill scale. We shall return to the relationship between capital burden and mill scale below. As for salaries, the decrease results from few additional staff being necessary as the mill scale increases.

The following elements are essentially independent or semi-independent of mill scale: pulping chemicals, purchased pulp, paper additives, steam and power, wages, consumable and maintenance materials, and water and effluent treatment chemicals. To the extent that their unit costs do change with scale, they usually decline.

This leaves three principal elements: wood, wastepaper and finished product delivery cost. Due to the delivery component common to them all, all three generally increase with increasing mill scale. Thus wood and wastepaper have to be brought in from progressively greater distances, and the finished product transported to customers increasingly far afield. The actual pattern of cost increase will of course depend on the respective distributions of fibrous raw material availability and finished product demand.

The picture of increasing mill scale is thus one of competing economic influences leading to the likelihood of an optimum mill scale for each set of circumstances.

ROR curve and its implications for investors

To see how these influences interact, it is convenient to borrow from Eklund's work.[1] The purpose of his original article was to demonstrate the superior economics of forest industry integrates. His data have been used here to derive Figure 2. Basically it illustrates the influence of mill scale on the rate of return on capital (ROR—cash flow per investment requirements) for five different types of mill. Three of the curves show fairly flat peaks, one levels off, and one keeps on climbing, albeit at a decreasing rate.

The maximum ROR, in all cases except the newsprint mill (Curve 4), occurs at around the 900-ton/day level. From a technical viewpoint, this corresponds approximately to the then-current limit for a single pulping line. However, from a financial point of view, 900 tons/day may not be the optimum scale. For

example, for Curves 1, 2 and 5 it might be decided to adopt the 600-ton/day level. The ROR would then be only 1% lower, but the capital requirement would be reduced by 20%. Market saturation considerations might also support this approach.

The absolute level of the curve is also relevant. Thus, for example, mills showing a high rate of return (Curves 3 and 4) could be accepted at a lower tonnage level than those showing a lower return (Curves 1 and 2).

Eklund's data refer to hypothetical mill models representing Finnish conditions in 1969. Since then, ROR has dropped, thus effectively lowering the curves in Figure 1. The models have also been tested against actual Scandinavian conditions. Steeper curves resulted where larger one-line production units had become technically feasible or wood transportation costs proved more favorable. "Steeper curves" initially rise somewhat more steeply and flatten further to the right of the diagram.

The bulk of Finland's production is exported and it is worth pointing out the correspondence of scale between the wood pulp mills in Figures 1 and 2. It is also worth drawing a rough parallel with the large export pulp mills being created in some developing countries and suggesting that they might be better off around the 600-ton/day level than near the 900-ton/day level. In their domain there are the additional considerations of raising the necessary capital and the influence of poor mill performance on the country's economy.

Bagasse, wheat straw and esparto grass, which are normally pulped in horizontal continuous digesters, usually show a maximum at the 200 tons/day level. This corresponds to the largest such digester currently available. In addition, due to the slower drainage of these materials, the brown stock and bleach plant washers are approaching the largest sizes manufactured. At low tonnage levels acceptable returns can be obtained using batch digesters. In fact in practice there can be more than one maximum on the curve, albeit at different levels of ROR.

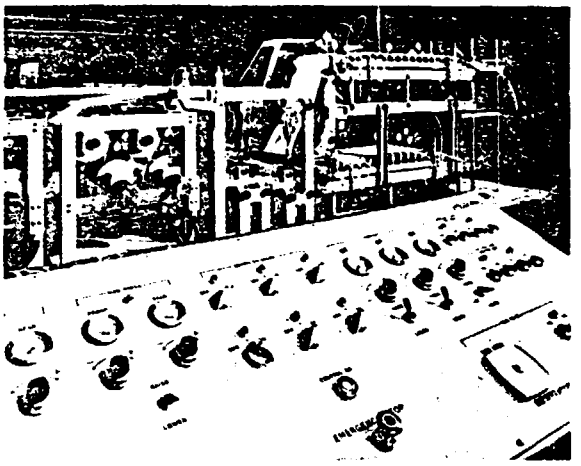
Rice straw is usually cooked in relatively small batch digesters and so does not benefit to such a degree from the scaling up of a single line. In addition, rice straw black liquor cannot be recovered because of its high silica content, so that a large volume may be difficult to dispose of.

From what has been said so far, it is evident that the absolute level and shape of the ROR-versus-mill-capacity curve are highly relevant to the selection of optimum scale. If the curve is pitched at a high absolute level due to such factors as favorable unit costs, selling prices or capital burden, an acceptable financial return may be achieved at relatively small scale. In the developing countries, incentives, such as high import duties (up to 75%) and tax holidays, are provided to make this possible. The actual shape of the ROR curve depends on the interplay of the various influencing cost elements as the scale of the mill increases.

Often developing countries wish to export a part or all of their production so as to turn their local raw materials into hard currency. Equally often, the additional delivery cost and unprotected selling price serve sharply to reduce the financial return.

Geographical, technical and economic variations

Different processes in our industry are variously described as capital intensive, raw material intensive and energy intensive. From a financial viewpoint this means that the unit capital burden, raw material or energy cost accounts for a significant proportion of the total delivered cost of the finished product. It is also possible for a process to be intensive in more than one of these cost elements, although they may be mutually exclusive. As for labor intensivity, large numbers of people are often employed in developing countries, particularly for raw material collection and finishing operations. Yet, due to low prevailing wage rates, they do not make a significant impact on the total economics.



Never too small? Pilot plants may be commercially viable.

A few examples serve to illustrate these three forms of intensivity. For a large new market pulp mill on the US west coast operating on cheap wood (mainly residues) the cost of such wood might be around 20% of the delivered pulp cost, while the unit capital burden could be double that. By contrast, a similar new Scandinavian mill, with its higher wood cost, could be paying around 40% for its wood and about the same in capital burden.

TMP plants are said to be energy intensive. Operating on cheap wood residues, a small TMP plant (50 tons/day) might have about equal unit costs for wood, power and capital burden, say 25% each. At the 150-ton/day level, capital burden would drop to 15% and the other two components increase to about 30% each. When operating on roundwood, the wood cost is proportionately greater.

Parenthetically, one can note that old mills, with little or no outstanding loan debt and essentially written-down assets, appear to have a small unit capital burden but correspondingly greater unit costs elsewhere. Inflation accounting philosophy, which bases depreciation on the replacement value, shows that this picture is rather misleading.

The fact that unit energy costs are semi-independent of mill scale permits us to narrow the field down to two prime influencing elements, namely capital burden and raw material. Since delivery is common to the delivered price of wood and wastepaper, as well as to the mill net-back (sales price minus delivery), it is more useful for the present purpose to consider delivery alone. Capital burden and delivery are usually the main opposing factors that produce maxima in our ROR-versus-mill-

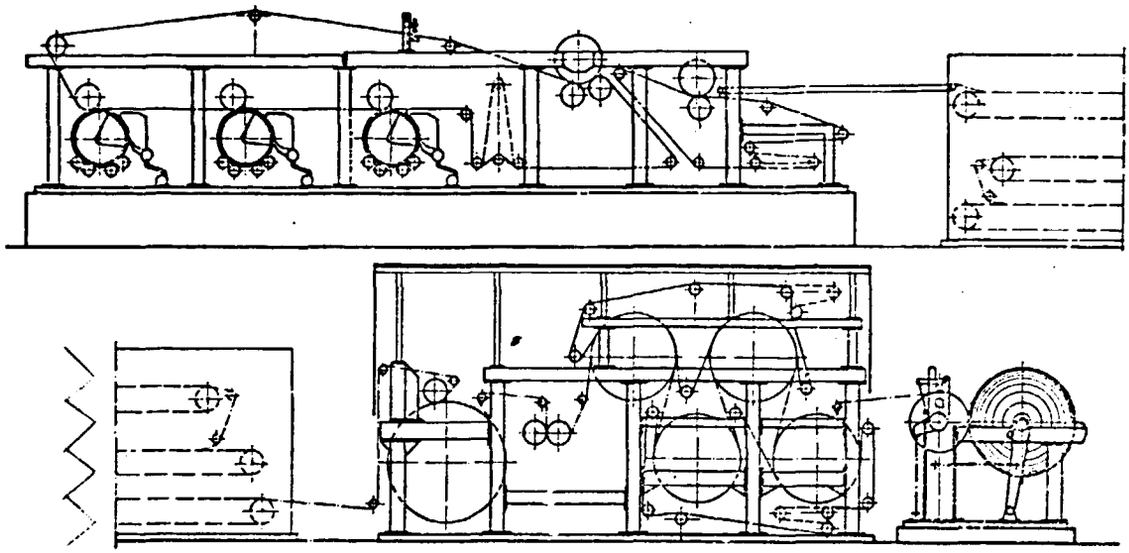
capacity curve, and it is therefore worth examining the effect of scale upon them.

Let us consider capital burden first. In engineering generally there is the "power of 0.6" rule-of-thumb guide to costs, which effectively says that doubling the capacity of plant increases the capital cost by around 52%. This is necessarily an approximate average figure. In our industry, extreme values of about 30% and 90% can be encountered. Kraft pulp mills with a single Kamyr cooking line lend themselves to low percentage figures, while mechanical pulp mills give high values.[1] In these two cases, increased scale is achieved by different physical means. In the first case, one set of units (digester, etc.) is enlarged to around the 1,000-ton/day level, while in the other case the number of individual grinder or refiner units is increased. Paper mills costs increase at around the 60% level. Obviously the inclusion of an additional unit (pulping line or paper machine) to achieve higher capacity pushes the percentage figure up somewhat.

From the point of view of financial return, it is the unit capital burden that counts. The 60% figure for paper mills corresponds to a reduction of unit capital burden by 20% when the mill size is doubled. Similarly, the above extreme figures of 30% and 90% translate into reductions of 35% and 5%, respectively. However, since the 30% equipment configuration may well have a higher absolute unit capital burden at the lower scale, these scale reductions help bring them closer together.

For small-scale versions of usually large-scale equip-

Profile of the Krafft paper machine and its uses



First of the mass production machines? Simple design and frequent orders—five so far installed—could make the Krafft paper and machine suitable for many small mills in industrial countries. Above dryer section, top wet-end.

The machine derives its name from the manufacturer, Carl Krafft & Söhne of Düren, Fed. Rep. Germany. Typically it produces waste-based corrugating medium and testliner in the basis weight range 100-300 g/m². Since it has three to five formers, other multi-ply grades within this range can also be run. The maximum trim width is 2.45 m, thus making it suitable for similarly wide corrugators. However wider deckles, up to 5.0 m, are possible to accommodate combinations of corrugator widths. Maximum machine speed is intentionally kept low at about 180 m/min. Typically the output of salable paper is around 70 tons/day at an average basis weight of 120 g/m². At present five machines are in operation.

A simple waste plant is designed to treat the grades of wastepaper available plus any purchased pulp. The paper machine commences with three to five formers. Fans, rather than vacuum pumps, maintain the vacuum. In the event of a wet end break, automatic controls clear the broke and start production again. A double-nip press is followed by a high-pressure felted press.

The pre-dryer section is of particular interest. The expense of dryer cylinders is circumvented by adoption of a Dornier dryer. The paper web is carried on a light wire-mesh conveyor and fans circulate the drying medium under controlled evaporation conditions. Heating up to 260°C may be by indirect (steam or circulating oil) or direct means, but direct heating with gas, where available, usually gives optimum economics. Power consumption falls into the range 10-30 kWh/ton of production. Relatively tension-free drying enhances paper quality. The dryer tiers can be stacked so as to fit available space.

Upon leaving the pre-dryer, the web wraps around a 2-m-diameter drying cylinder. This serves to enhance the surface of linerboard. There follows a size press (optional) which can be used to improve the CMT properties of corrugating medium, and four or more 1.5-m-diameter after-dryers. The machine is driven by a thyristor-controlled DC drive.

The machine house is also simple. No basement is required and the machine itself can be housed within a volume 10 m wide by 75 m long by 8 m high. Steam requirements are generated in a small heater so that the boiler house is eliminated.

Manning is also low, for the machine can be tended by two men. Where two machines are installed in close proximity, one winder can serve both machines.

ment, the unit capital burden accounts for a particularly large proportion of the delivered cost of the finished product. This is the principal reason for the rapid initial rise in the Figure 2 curves. It follows that small-scale installations should not be purely scaled-down versions of larger mills, but rather should use an appropriate level of less capital-intensive technology where possible.

It is unfortunately more difficult to make generalizations about delivery costs. This results partly from the fact that the distribution of fibrous raw material availability and finished product demand are different for every mill, and partly from the combinations of possible transport methods. One can say that the cost of transporting wood, with its high moisture content, is usually the most significant factor. For low yield processes (chemical pulp), the impact on unit wood costs is greater than for high yield processes (mechanical paper). However, since the unit capital burden of the former tends to be reduced by increases in scale to a greater extent than the latter, there is a certain offsetting influence here.

For transport by ship, handling at both ends is quite expensive and best value per unit of distance is usually obtained on the longer sea hauls. The cost of land transport is more closely proportional to distance. For transport of all forms of finished product the effect of higher energy prices has reduced somewhat the attraction of shipping to distant markets.

Present state of the art of building small mills

Having discussed the principles, let us now examine the present state-of-the-art with respect to small mills. We will start with the Krafft paper machine, for it elegantly illustrates our criteria for small scale (see profile inset). It is noteworthy that all five machines are installed in developed countries (Netherlands and Fed. Rep. Germany). The machine is usually at its best located next to a large corrugating plant. There it can use the broke waste from the plant directly and buy in the balance of its wastepaper requirements. Thus delivery costs on both raw material and finished product are kept to a minimum.

For the reasons outlined in the inset box, capital and operating costs are also low. In fact the unit capital burden of such a mill equals that of one with a larger and faster paper machine of about three times its capacity. Contributory factors in the saving of capital and energy are the relatively narrow deckle and low speed. The latter also helps to reduce clothing and manning costs. Production of the machine as a fairly standardized item on suitably sized machine tools also adds to cost efficiency.

The machine as a concept is a breakthrough, although it contains no new technology. Rather it is the product of good economic analysis of the cost elements in combination with sensible engineering approaches to minimize them. In some respects it is a scaled-down version of large-paper-machine technology, while in other respects a different approach has been taken.

The Krafft machine falls into the lower end of the range for "Wastepaper" shown in Figure 1. The figure similarly summarizes the current state of the art with respect to scale. Wastepaper and rice straw can already be made into certain paper grades on an adequately small scale. In this context small MG and reconditioned secondhand paper machines are used extensively to produce waste-based products in the lighter substances.

For the other main non-wood fibers (bagasse, wheat straw, bamboo, reed and esparto grass) the economic level is somewhat higher and the capital involved can represent a problem for developing countries. The situation becomes even more acute in the case of wood, although the viable level can be reduced somewhat by integrating with residue-producing sawmills. Thus this is the area where technological improvements are most needed.

One aspect of the problem is chemical recovery. The conventional recovery boiler is not economic until around the 200-ton/day (of pulp) level and at present there is no really inexpensive alternative available for smaller tonnages. In the existing approaches (Babcock Krauss-Maffei, Broby, Copeland and Zimpro) savings in capital are sometimes achieved at the expense of heat recovery, and they all require recausticizing (and possibly a lime kiln) if the caustic soda is to be regenerated.

TMP plants have been installed at impressively low scales. Thus of those announced to date, about 30% have been below the 100-ton/day level and 65% below the 200 ton/day level. We have already shown that their economics are relatively insensitive to scale. Rather, their justification is based on TMP's ability to displace chemical pulps. Suitable cheap wood residues and inexpensive power naturally help the economics.

The other main area where there is a need for new thinking is that of non-integrated paper mills. Simply stated, the requirement is for a mill that can profitably produce paper on a small scale from purchased pulp. Dry forming was expected to make this possible at one time, but has not fulfilled its initial promise.

Pilot plant machines and their unsuspected potential

Extrapolating the argument for small machines, it can be seen that the pilot-plant-scale paper machines (Figure 3) located at research establishments and academic institutions may indeed be viable commercially. Normally they are both used in-house and rented to outside users. To the extent that their operating time is not fully taken up, they might usefully supplement R&D budget funds.

Capital outlay should be little or none, since most of the equipment probably already exists. Many of these machines are already highly automated. Supplementary automation might be justified to permit automatic running, including use of the "night shift." Automatic shut-down of the system could occur in the event of a break. The necessary raw materials could be obtained at bulk prices from associated companies. Imaginative products of a high added value, such as notepaper with a personalized watermark, would be marketed either locally or through associated company sales organizations. Given the paucity of these machines and their low individual output, world overcapacity is unlikely to be a problem. Small scale coaters and other pilot plant equipment might similarly play a part.

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Dr. Grant is PPI's national editor for the United Kingdom and projects director of Reed Engineering and Development Services Ltd.

Small mills may be the only solution

In developing countries small pulp and paper mills are not just justified but, in many cases, are the only alternative. Often based on non-wood fibers, a developing country's first mill can give it practical experience for expansion when demand grows. New technology must be developed specifically for small units, insists Harry J. Hackl.

Not enough consideration has been given by governments, clients, suppliers and financing authorities to the advantage of small pulp and paper mills for developing countries.

The tendency in the traditional paper producing countries to constantly increase unit capacities of pulp and paper mills was somehow transferred to new mill projects in developing countries. This proved to be a mistake in many cases and has led to a number of new installations which turned out to be failures because they were not developed in accordance with the possibilities and requirements of the clients, countries or market conditions.

When talking about "small" mills it is necessary to first define what is meant by "small." Compared to a woodpulp and paper mill with a capacity of 600 tons/day, a mill of 200 tons/day might be considered "small" and below the minimum economic size. We, however, talk about developing countries. In most of the cases in developing countries, a 200-ton/day mill can be termed a large operation.

Most of the developing countries start their own pulp and paper industry on raw materials other than wood. For non-wood-fiber pulp and paper mills based on straw, bagasse, reed, grass, etc., a 200-ton/day mill is a very large unit. In fact, in such countries the capacity of mills very often is only 50 tons/day or even lower.

This is proven by the figures in Table 1. We have tried to compile all non-wood-fiber pulp mills which have been established worldwide since about 1965.

An analysis of Table 1 shows:

- 23 mills of 10-70 tons/day
- 10 mills of 70 - 120 tons/day
- 9 mills of 120 - 200 tons/day
- 3 mills of above 200 tons/day

Therefore, more than 50% of all these mills have capacities of 70 tons/day or less, with most of the small mills in the 25-60-ton/day range. For various reasons it can be expected that, in the future, the developing countries will still produce more small pulp and paper mill projects based on non-wood fibers than large projects. Here are some reasons for this.

TABLE 1 – NON-WOOD FIBER PULP MILLS BUILT SINCE 1965

Name of Mill	Country	Capacity air-dry metric tons/day	Raw Material
1 Letjes	Indonesia	22	Rice Straw
2 Klabin Ponsa	Brazil	40	Bagasse
3 North Bengal Pulp & Paper Mill	Bangladesh	60	Bagasse
4 Central Pulp Mill	India	120	Bamboo
5 Orizaba I	Mexico	80	Bagasse
6 Pudumjee	India	25	Rice Straw
7 Illigan	Philippines	40	Abaca/ Bamboo
8 Curitiba	Brazil	25	Grass/Straw
9 Basrah I	Iraq	70	Bagasse/Reed
10 Banjuwangi	Indonesia	30	Bamboo
11 Valaichchenai	Sri Lanka	30	Rice Straw
12 Tejke	India	40	Rice Straw
13 Pakistan Paper	Pakistan	90	Bagasse
14 Chung Hwa Pulp	Taiwan	200	Bamboo
15 Calumpit UPPC	Philippines	50	Bagasse
16 Pars Paper I	Iran	60	Bagasse
17 Mostaganem	Algeria	180	Esparto grass
18 Saica	Spain	40	Wheat straw
19 Sylhet	Bangladesh	80	Bamboo/Reed
		+ 20	Jute
20 Isarog	Philippines	10	Abaca
21 Saida	Algeria	80	Rice Straw
22 Pars Paper II	Iran	150	Bagasse
23 Menzi	Philippines	10	Abaca
24 Taiwan Sugar Co	Taiwan	250	Bagasse
25 Embilipitiya	Sri Lanka	40	Rice Straw
26 Afyon	Turkey	170	Straw/Reed
27 Stranger Pulp & Paper Co	South Africa	150	Bagasse
28 Basrah II	Iraq	120	Reed
29 Nagaland I	India	50	Bamboo
30 Nagaland II	India	50	Reed
31 Mocarpel	Venezuela	150	Bagasse
32 Olmuk	Turkey	70	Straw
33 Loreto	Mexico	80	Bagasse
34 Induperu	Peru	250	Bagasse
35 Misan	Iraq	150	Bagasse/Reed
36 Deir ez Zor	Syria	100	Straw
37 Letjes II	Indonesia	40	Rice Straw
38 Papel Periodico	Mexico	300	Bagasse
39 Samchong	South Korea	20	Rice Straw
40 Orizaba II	Mexico	200	Bagasse
41 Rakta	Egypt	100	Rice Straw
42 Thai Pulp Co.	Thailand	150	Bamboo
43 Kastamonu	Turkey	15	Cotton Linters
44 Lepenka	Yugoslavia	50	Straw
45 Kerala	India	100	Reed

Why small mills will continue

Small mills will be built mainly in countries which do not have an established pulp and paper industry. Some of them might have enough wood resources for a mill, but in many cases it is not possible to economically exploit such resources due to a lack of infrastructure.

The developing countries have vast resources of non-wood raw materials readily available and easily accessible. It is, therefore, logical that they base their mills on such materials as rice straw, cereal straw, sugar

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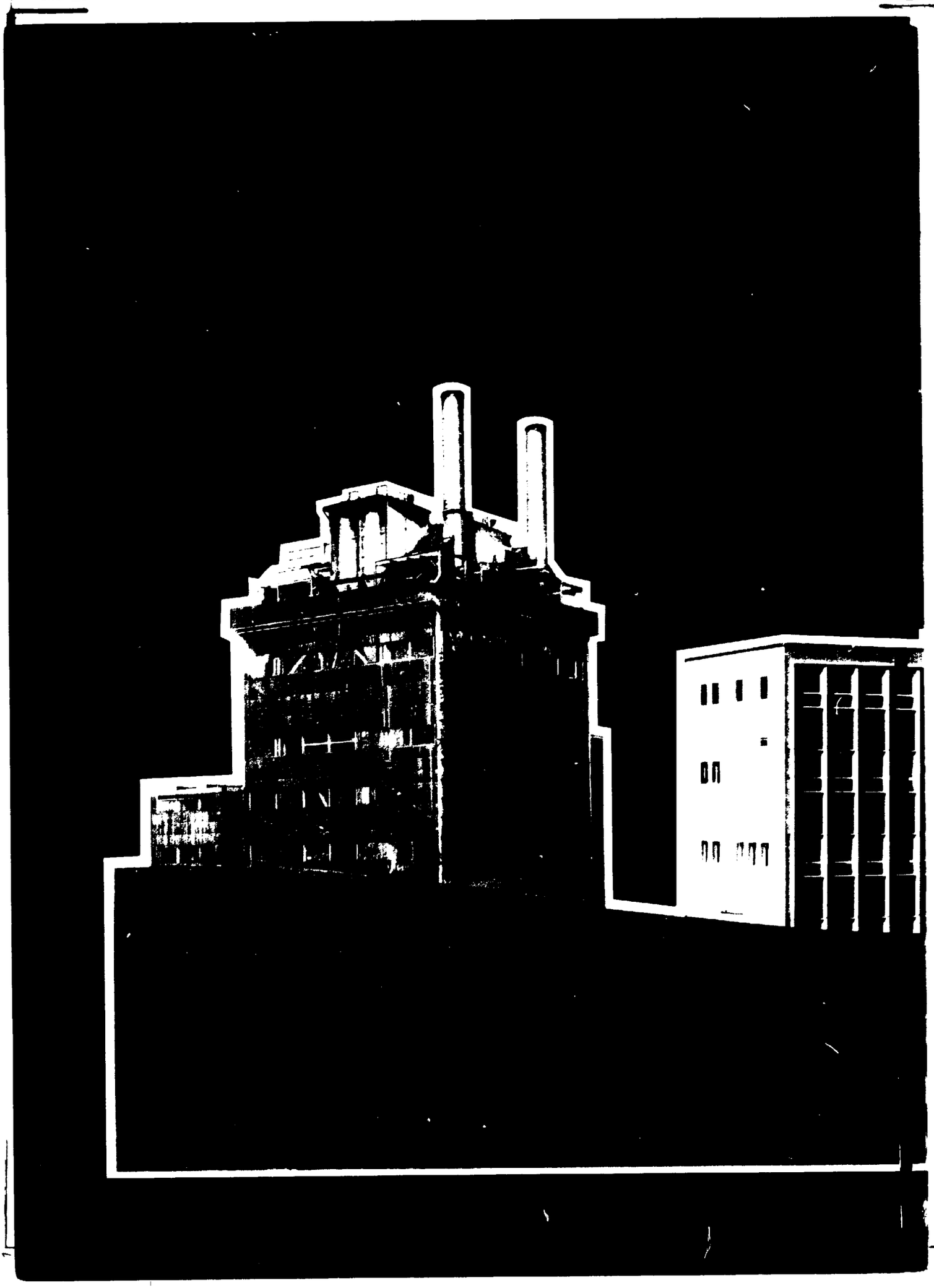
incorporate the practices of REEDS Limited and Sanderson Watt & Company



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