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Chile.

ASSIST:NCE TO THE INSTITUTO FORESTAL

IN INDUSTRIAL UTILIZATION

OF WOODWASTE

UC/CHI/83/192

CHILE

Technical Report *

Mission 2 December 1984 to 16 April 1985

Prepared for the Government of the Republic of Chile
by the Uni ed Nations Industrial Development Organization,
acting as executing agency for United Nations Development Programme

Based on the work of K.H. Kehr,
expert in energetic conversion of forest residues

United Nations Industrial Development Organization
Vienna

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SUMMARY

In the last 15 years Chile increased its pine plantations to 1.1 million hectares. The plantations will come up to almost 2 million hectares at the end of the century. This area will occupy only half of the unused forest land, located mainly in the coastal and central strips of the medium part of the country (Region V to X). Native hardwood forests in the South and at the foothills of the Andean massif in the medium part of the country are not considered in this study due to lack of impact in relation to actual management and industrial use. Forestry participates - as second but one behind copper (47 %) - with 10 % in the total exports and with 2,5 % in the GNP.

Considering the next 15-year period (1985 - 99), residual wood is estimated and projected on communal level as the sum of non-merchantable roundwood of low quality (pulpwood standard) plus silvicultural and industrial residues. This has been done by computerized simulation of growth, silvicultural treatments, final cropping and demand for traditional forest products as sawlogs and pulpwood taking in account local impact of already installed and projected processing facilities as sawmills, pulp and paper factories and particle board manufacture.

Estimation and projection of fuelwood and charcoal demand - also simulated by computer on communal level - is based on the actual consumption per capita and population increase - both rural and urban - in the residential sector and in the industrial sector, on total final energy consumption and on participation patterns of wood and its derivates in the past.

The participation of wood grew from 13,6 % - after a decline from more than 23 % in 1963 - to 19,8 % in the period from 1972 to 1983 and is likely to increase to almost 30 % at the end of the century. This approach widely considers substitution of fossil fuels in residential as well as industrial sectors. Deducting local energy demand for fuelwood and charcoal from the local availability of residual wood there will be an increasing volume of excess wood on communal level which will amount to 10 million solid m^3 (4.5 million BDT) - or in energy terms 19 000 Tcal or 80 000 TJ - annually, on an average and nationwide, in the last five-year period (1995 - 1999).

This energy of excess wood corresponds to about 20 % of the total final energy consumption of the country which is imported at present to the extent of about 30 %. Energy costs of excess wood are compared with costs of fossil fuels in relation to steam costs produced in boilers on industrial scale, yielding substitution rates of up to 5.6 : 1 in the case of fuel oil and of up to 2.0 : 1 in the case of mineral coal, considering all prices at the fuel's site of origin. Therefore the economics of specific conversion or substitution projects largely depend on the transport economy of excess wood or its derivates. In the recent past, however, the country has already substituted about 300 000 metric tons of fuel oil (about 3 000 Tcal or 12 600 TJ) by excess wood and large substitution projects are actually under way on industrial scale.

For that reason no new project on direct combustion of wood for heat and power production is identified in this study. However, four new projects are recommended on the fields of pyrolysis, gasification, liquefaction/hydrolysis/fermentation and indirect combustion in order to convert excess wood in energy, chemical feedstocks and chemical products. Highest priority is given to a mobile pyrolysis unit for integral carbonization yielding charcoal, pyrolysis oil and gas, which could be operated in the forest. The second priority is given to gasification equipment for stationary and mobile units - already existing and burning fossil fuels or not - with excess wood or charcoal as raw material. The third and fourth priorities are given to ethanol/protolignin production for substitution of liquid fuels, chemical feedstocks and imports, and to the production of carbon blacks as import substitution.

INTRODUCTION

1. The Technical Report in Spanish language - under the title "Uso Industrial de la Madera del Pino Insigne (Pinus radiata D. Don) - is still in the editing phase and would be available midth of May 1985 in its final version. The editing work is carried out by the Instituto Forestal of Chile.

2. In its very early stage, the intention of the project was the utilization of forest residues and industrial wood waste as a raw material for particle board production. In view of the high capacities of such production already installed in Chile - and even worldwide - the Chilean Forest Institute proposed a study on the energetical conversion of forest residues which has been chosen as the principal objective for the special mission and expert's assistance to the Forest Institute.

3. Basically, the corresponding job description 1/ proposed the expert's assistance on establishing a programme on the utilization of residues coming from both forest management and forest industry and woodworking activities. In principle, the programme should consider the generation of energy of such residues including technical problems, transport and marketing of the final products.

1/ see Annex 1 "Descripción del Puesto"

4. In his special function the expert should assist the institute in the implementation of the project's objective, forming part of a local team composed by a forest engineer, financial analyst and an economist. The final task of the team was to determine the three best suitable possibilities of energy conversion for the Chilean case, regarding the utilization of wood residues and giving priorities. The possibility with the highest priority proposed - considering its short-term implementation - should be presented on the level of a Prefeasibility Study.

BACKGROUND

5. In the past fifteen years Chilean enterprises planted some 1.1 million hectares of pine (Pinus radiata D. Don), and some 50 000 hectares of eucalyptus (Eucalyptus globulus Labill.), stimulated by generous state-financial incentives. These incentives cover practically the reimbursement of almost the total plantation costs, except the costs of land. This immense plantation activity took place on unused and cheap forest land, with a total potential of more than 4 million hectares.

6. It is to be expected that 50 000 hectares would be planted yearly, coming up to a total plantation area of almost 2 million hectares at the end of the century. This area would occupy only half of the available unused forest land. This forest land is located exclusively in the coastal and central zones of the country already denude from native hardwood forests during the last century and unsuitable for any agricultural use.[+]

[+] see Map of Chile

7. Most of the southern regions are unsettled and widely stocked with native hardwoods as well as parts of the foothills of the Andean massif in the medium regions. These hardwoods have not been considered in the project because they are traditionally used by the local people as sawn timber and fire-wood, with small industrial impact.

8. Principal data on the Chilean forest sector give a picture of its potential and its magnitude, as follows:

- forest land incl. unused, protection and production forests	40 % of total land area (75,7 mill. ha)
- occupation (1980)	80 000 persons or 7 % of total population of 11,7 mill. (1983)
- production value (1980)	US $ 780 mill.
- export value (1980)	US $ 468 mill.
- port demand (shipping weight of timber and timber products)	2,1 mill. metric tons
- percentage forest products of total export (1980), second but one after copper (47 %)	10 %
- participation of forest sector on Gross National Product (1980)	2,5 %
- consumption of forest products in primary forest industries (1980)	9,1 mill. m^3 (equivalent to some 18 000 ha annual clearcut area)
	divided in:

sawlogs	50,0 %
pulpwood	31,0 %
roundwood (export)	11,6 %
newspapers	2,8 %
boards	2,4 %
others	2,2 %
	100,0 %

- consumption of fuelwood (incl. charcoal in fuelwood equivalencies) — 8 kg per household/d (5 members per household)

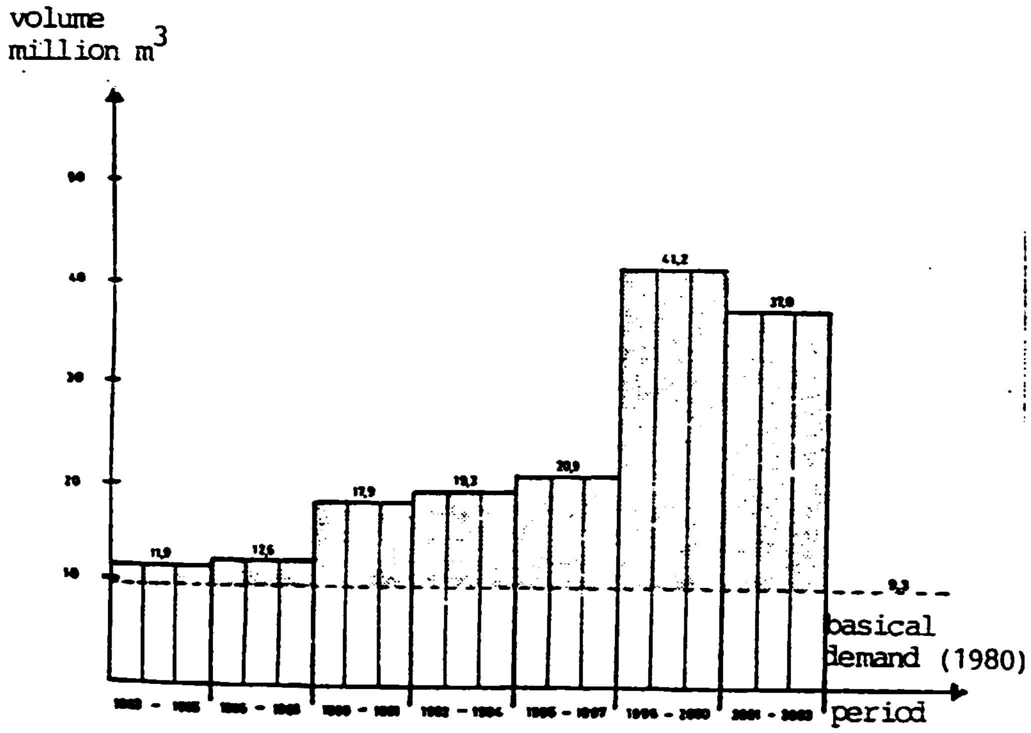
- projection of yearly timber (roundwood) availability of standing pine wood by type of potential utilization (mill. m^3)

Period	Sawlogs	Pulpwood	Total per year
Base 1980	6 650	3 516	10 166
1983-85	8 129	3 816	11 945
1986-88	8 044	4 611	12 655
1989-91	10 627	7 242	17 869
1992-94	10 318	8 975	19 293
1995-97	12 600	8 356	20 956
1998-2000	26 356	14 867	41 223
2001-03	24 806	12 204	37 010

- average distribution of roundwood availability according to regions (period 1985 - 2000)

Region	Percentage of total roundwood availability %
VIII	57
VII	16
IX	13
X	7
VI	5
V	2
	100

9. Availability projection in relation to the demand based on the year 1980 shows the following figure:



This relationship between future availability and actual demand of standing pine wood on national level indicates that there would be an increasing surplus of roundwood to be marketed, coming up to the fourfold volume at the end of this century, in comparison with the year 1980. The following table shows the yearly surplus of disponible standing pine timber and its relationship with the 1980's volume.

Period	Annual Surplus (mill. m^3)	Percentage in rel. to 1980
1983-85	1 779	17
1986-88	2 489	24
1989-91	7 703	76
1992-94	9 127	90
1995-97	10 790	106
1989-2000	31 057	305
2001-03	26 844	264

10. Actu: .ly it is to be expected in the best of the possible cases that only half of the surplus of standing pine timber could be sold as traditional forest products (sawlogs and pulpwood), considering projections on national and international markets. The remainder consists practically of non-merchantable roundwood of pulpwood quality (diameters from 10 - 19 cm), including sawlog diameters (more than 20 cm). The latter is of inferior quality and not merchantable as sawlog , due to the lack of silvicultural treatment in the past. Together with the major forest residues (diameters from 5 - 9 cm) this remainder from timber explotation activities is called in this report "residual roundwood" which in former studies was estimated at very considerable yearly amounts increasing from about 2 to 10 million BDT 1/ until the end of the century.

Forest residues from delimbing and thinning activities during silvicultural treatment and industrial residues from milling of sawlogs, resawing of cants etc. are not yet considered within these figures.

1/ BDT = bone dry tons (metric)

I OBJECTIVES

11. Considering the magnitude of the available residual wood from silvicultural and industrial activities the project has been expanded from its original target of energy conversion of forest residues to the identification of industrial use of excess wood for non-traditional forest products as

- energy
- chemical feedstocks
- chemical products.

In accordance with the Government's policy, the project is aiming to:

- substitute imports;
- substitute fossil energy and feedstocks; Chile imports actually (1983) about 30 % of its final energy consumption (about 100 000 Tcal[+/]) from which 90 % is consisting of crude petroleum and 10 % of mineral coal;
- cover partially the costs of standing pine volume of plantations highly subsided by the Government;
- ease financial liquidity to the investor before final cropping at the end of the rotation - normally 24 years at average [illegible] conditions - by utilization and local conversion of intermediate products as residual wood from thinning

+/ Tcal = Teracalorie = 10^{12} calories
= 4,19 TJ (Terajoules)

activities. Delimbing residues are classified as fine and minor residues only, which are not considered in this project due to their high collection and transport costs within the forest plantation (see Glossary).

- ease financial liquidity to the investor in case of marketing problems due to the expected surplus of traditional forest products;
- increase the return on investment;
- create investment opportunities in remote regions;
- develop non-traditional export products.

II METHODOLOGY

12. Successful development of energetic chemical conversion of residual wood will mainly depend on the distribution of local supply and demand within subregions, rather than on its total inventory or availability. Fresh wood is a raw material with high moisture content and low calorific value or energetical density. Therefore the transport of residual wood is limited and conversion has to be taken place as near as possible to the site of origin.

13. On the other hand local wood energy demand in residential as well as industrial areas is significant - about 20 % of total energy consumption or about 20 000 Tcal/year; 50 % of all households (about 2,4 mill.) are using fuelwood or charcoal as basic energy for cooking and heating - and will come up to about 30 % till the end of the century due to the increase of population and substitution of fossil energy.

14. Moreover, the Forest Institute had just finished inventories of pine plantations from the fifth to the ninth region including processing and storage in its own computer system.

15. Since this project should identify the possible industrial use of residual wood on a long-term basis the following parameters for the three next five-year periods (1985 - 89, 1990 - 94, 1995 - 1999) have been investigated:

<u>On communal level</u>

(There are almost 300 communities, about 50 provinces and 12 regions in Chile).

- Availability of timber based on the computerized management simulation of existing pine plantations, including new plantations of 50 000 hectares yearly as well as silvicultural and industrial residues. The simulation was programmed and executed by the project;

- demand of traditional forest products as sawlogs for export and local sawmilling and pulpwood, taking into account installed local capacities of sawmills and pulpmills and its already identified expansion in the 15-year period. The export volume of sawlogs has been taken from existing estimates, coming up to about 1 mill. m^3 roundwood per year;

- balance between availability of timber and residues and demand of sawlogs as well as pulpwood in order to determine the availability of residual wood;

- energy demand - both rural and urban - on residential and industrial level including fuelwood and its "derivates" (sawdust, bark, charcoal) and fossil energy which could be substituted by fuelwood and/or its derivates;

- balance between availability of residual wood and demand of fuelwood and its derivates in order to determine the excess of residual wood on communal level. This excess has to be transported to conversion centres, in its original form or to be densified mechanically to bundles, briquets or pellets.

On provincial, regional and national level

- Alternatives of mechanical densification and chemical conversion of the excess wood;

- transport economy of excess wood;

- development path on chemical conversion of excess wood according to the Chilean case.

III BALANCE OF EXCESS WOOD

16. In accordance with the results of the forest management simulation the average annual production of commercial roundwood will be in the range of 20 mill. solid m^3, considering the last five-year period (1995 - 1999). In peak years the production will increase up to 40 mill m^3. In the same period, silvicultural and industrial residues are estimated at about 6 mill. solid m^3 per year on an average level.

17. The demand for sawlogs and pulpwood in the last five-year period would be in the range of 10 mill. solid m^3, leaving behind a non-merchantable volume of another 10 mill. solid m^3. Since the residual wood volume is defined as the sum of non-merchantable roundwood plus the volume of silvicultural and industrial residues there would be an annual availability of residual wood of 16 mill. solid m^3.

18. The energy demand on communal level has been estimated in 6 mill. solid m^3. This volume has to be deducted from the availability of residual wood on communal level again, giving a volume of excess wood of 10 mill. solid m^3 or about 19 000 Tcal [5/]. This means that - after covering the local demand of fuelwood and its derivates on communal level - there would be a nationwide volume of excess wood - of above mentioned amount - to be converted in energy, chemical feed-

[5/] 1 Tcal = 235 BDT = 522 solid m^3

stocks and chemical products. In terms of energy this volume corresponds to about 20 % of the total energy consumption of the country. Furtheron, this means that part of the possibly expected increase in total energy consumption till the end of the century - to be caused by higher industrial growth - could be covered additionally by excess wood besides the already discounted substitution of fossil energeties by residual wood on communal level. Of course, any unforeseen and therefore not considered increase in demand of traditional forest products as sawlog and pulp export must be satisfied with preference by this immense volume of excess wood. However, it is very unlikely that the already considered demand for traditional forest products would be exeeded till the end of the century due to constraints on national and international markets and available investment capital.

IV CONVERSION ALTERNATIVES

19. After discussing already existing conversion techniques in Chile, the following technical and economical alternatives of densification and conversion of excess wood have been considered:

a) Mechanical densification

- bundling
- briquetting
- pelletting.

b) Chemical conversion

- carbonization
- combustion
- gasification
- liquefaction
- hydrolysis.

Table 1 indicates some technical and economical parameters of existing cases of chemical conversion of wood biomass, as follows:

Table 1: TECHNICAL-ECONOMICAL PARAMETERS OF CHEMICAL CONVERSION ALTERNATIVES

Case #	Alternatives	Energy Recovery Case %	Energy Recovery Variation %	Specific Consumption of Wood BDT/a	Specific Consumption of Wood Tcal/a 1/	Products	Products Tcal/a	Investment Specific Input US $/BDT	Investment Specific Output US $/Tcal	Investment Total US $ mill.	Observation
	Carbonization										
1	- simple	36	20 - 40	3 500	15	charcoal	5,4	2	1 300	0,007	"Bee-hive" system/Brasil
2	- integral	78	65 - 80	21 000	90	charcoal, pyrolysis oil and gas	70	37	11 000	0,77	system TVA = Tennessee Valley Authority
	Direct combustion										
3	- cogeneration with turbines	53	40 - 60	18 000	77	steam and electricity	41	187	82 000	3,36	8 MW-thermal 1 MW-turbine/electricity
4	- cogeneration with steam engine	43	30 - 50	5 700	24,5	steam and electricity	10,6	338	192 000	1,93	2 MW-thermal 0,25 MW-steam engine/ electricity
	Gasification (Producer gas) Downdraft type										
5	- with wood	16	15 - 25	2 362	10	electricity	1,6	216	319 000	0,51	6 000 h/a, 20 % m.c. 3 x 150 kW electricity 0,7 local factor
6	- with charcoal	16	20 - 22	1 700 (charcoal)	10	electricity	1,6	72 2/	212 000	0,34	6 000 h/a, 20 % m.c. 3 x 150 kW electricity 0,7 load factor
	Updraft type										
7	- with wood	50	40 - 60	14 800	63,7	combustion gas	32	68	31 000	1,00	8 000 h/a 80 % of nominal capacity 5 mill. kcal/h
8	- with charcoal	67	65 - 70	8 000 (charcoal)	48	combustion gas	32	44 2/	25 000	0,80	8 000 h/a 80 % of nominal capacity 5 mill. kcal/h
	Gasification (Syngas)										
[illegible]	- methanol synthesis	56	-	825 000	3 547	methanol	1 996	151	63 000	125	7 920 h/a, 415 800 t/a
10	- ditto MOBILE alternative	49	-	825 000	3 547	gasoline	1 746	200	94 500	165	7 920 ha/a, 166 320 t/a 3/
	Liquefaction/ Hydrolysis/ Fermentation										
11	- ACOS-process 4/	75	-	23 760	102	ethanol, protolignin	77	179	55 200	4,25 7/	9 900 t/a ethanol 5/ 2000 t/a protolignin 6/

1/ 4 300 kcal/kg (18 000 kJ/kg of bone-dry wood

2/ in relation to quantity of wood to be carbonized

3/ 228 mill. litres/a, or 276 litres per BDT of wood

4/ Acid Catalized Organosolv Saccharification (ACOS)

5/ 12,5 mill. litres/per year

6/ It is to be assumed that 5 000 metric tons of additional protolignin would be burned for process heat.

7/ This investment has been increased by 50 % in relation to the investment of a pilot plant of same size, actually going into operation in Sao Paolo/Brazil.

V FINDINGS AND RECOMMENDATIONS

20. In the field of oil substitution by direct combustion of excess wood there exists widely experience in Chile and local as well as foreign consultancies are available. It can be assumed that in the last five-year period about 300 000 metric tons of oil were substituted annually by excess wood in Chile, corresponding to annual savings of about US $ 60 mill.

21. Table 2 shows the attractivity of oil substitution - and even of substitution of mineral coal - by excess wood, as follows

Fuel	Price US $	Calorific Value kcal/kg	Efficiency 5/ of Combustion System %	Steam Costs US $/Tcal	Cost relations based on Substitution of Fuel Oil	Cost relations based on Substitution of Mineral Coal
Fuel oil # 6	225/t	9 630	80	29 200	1.0	0.36
min. coal 1/	50/t	6 400	75	10 400	2.8	1.0
excess wood:						
-roundwood 2/	7.85/t 6/	2 500	60	5 200	5.6	2.0
-chips 3/	32.80/t 6/	3 000	65	16 500	1.8	1.6
-pellets 4/	67.00/t 6/	8 000	80	10 500	2.8	1.0

1/ underprized, with trend to 70 US $/t

2/ 70 % m.c. (moisture content)

3/ 45 % m.c.

4/ 15 % m.c., densification 2:1

5/ operation conditions: 11 bar, 100° C (saturated)

6/ price at roadside at forest

In the recent past considerable amounts of fuel oil have been substituted by excess wood and large industrial substitution projects are under way. Even mineral coal is envisaged for wood substitution by a large cement factory with own forest resources and sawmilling facilities, located only some 20 km from the coal mine.

Therefore no further study or project for external aid has been identified on combustion of excess wood.

22. Four projects are to be recommended for further studies since their implementation seems to be technically and economically feasible at this stage. These projects are listed according to their priorities as follows:

No. 1 - <u>Mobile Pyrolysis Unit</u>

for the integral carbonization of excess wood producing charcoal, pyrolysis oil and gas (see case # 2, Table 1).

This project has been given the highest priority because of

- conversion of excess wood within the forest saving considerable costs in transport of bulky and wet raw material;
- production of charcoal for development of the industrial charcoal market. This market seems to be highly potential but it is not developed due to the lack of supply. This unit would yield - under high energy recovery - the following products:

- 7 000 BDT/year of lump charcoal made from 21 000 BDT or almost 50 000 m^3 of excess wood;

- 3 000 metric tons of pyrolysis oil for sale. This oil could be mixed with fuel oil or could substitute completely fuel oil in existing boiler installation. The concept of recirculation of part of the hot pyrolitic gases to sustain the pyrolysis reaction - instead of air - yields a nearly corrosion-free and non-aggressive pyrolysis oil which could be handled as any other fuel oil;

- part of the off-gas would be used for own energy requirements of the unit and the other part could be used for heat and/or electric power production locally, p.e. tannin extraction unit from pine bark, electric power unit for electric chain saws etc.

Within the Technical Report a study on pre-feasibility level regarding this project is included (see para 1) .

No. 2 - Gasification Equipment (producer gas)

for mobile and stationary combustion engines and boilers with excess wood and/or charcoal as raw material.

This project has been given the second but one priority because of

- substitution of liquid fuels as petroleum derivates in remote areas and "island operations" as mining, forestry, road building by gasifying excess wood;
- substitution of liquid fuels in combustion engines of tractors and trucks as well as in boilers of industrial plants by gasifying charcoal with or without pyrolysis oil produced by integral carbonization or pyrolysis (see project priority No.1 and cases # 5 and # 6 of Table 1).

No. 3 - Pilot Plant for Ethanol and Lignin

using a combined liquefaction/hydrolysis process known as "Organosolv Wood Hydrolysis Process" or "Acid Catalized Organosolv Saccharification".

This project has been identified mainly because of

- production of ethanol for direct substitution of up to 20 % of gasoline in cars (gasohol);

- production of ethanol as chemical feedstock;

- production of protolignin (nearly unmodified) as chemical feedstock for glue production etc.;

- its suitability to convert large volumes of excess wood under a high energy recovery (see case 11, Table 1).

No. 4 - Plant for the Production of Carbon Blacks

using excess wood from pine.

This project has been identified mainly because of

- import substitution of more than 6 000 metric tons/year of carbon blacks for tyre and tube production and manufacture of inks and paints.

NACIONES UNIDAS

ORGANIZACION DE LAS NACIONES UNIDAS PARA EL DESARROLLO INDUSTRIAL

ONUDI

Asistencia al Instituto forestal para el Aprovechamiento Industrial de los Residuos de Madera

UC/CHI/83/192/11-01/32.1.I

DESCRIPCION DEL PUESTO

Título del puesto — Experto en la conversión energética de residuos forestales.

Duración — Tres meses.

Fecha de iniciación — Tan pronto como sea posible.

Lugar — Santiago de Chile, con viajes al interior del pais.

Propósito del proyecto — Proponer un programa para el aprovechamiento de los desechos forestales derivados de la explotación y manejo de los bosques y de los residuos de la elaboración de la madera, considerando su utilización en la generación de energía, estudiando los problemas técnicos, transporte y mercado de los productos finales.

Funciones — El experto asesorará al Instituto Forestal de Santiago de Chile con miras a la implementación del objective del proyecto.

El experto será miembro de un equipo que incluirá un técnico, un analista financiero y un economista del Personal del Instituto. En colaboración con los otros miembros del equipo, asesorá al Gobierno sobre las posibilidades de utilizar los residuos de madera para, de acuerdo al volúmen disponible, la producción y generación de energia. En particular, hará un diagnóstico de:

- Volumen, costo, tipo y calidad de los residuos y desechos de madera disponibles.
- Costos en sitio y problemas de transporte y almacenaje.
- Evaluación de las alternativas de conversión energética de estos productos, según las mejores technologiás existentes y que sean más relevantes para el caso chileno.
- Determinación de las tres mejores posiblidades de conversión energética para el caso chileno en orden de prioridad.
- Elaboración de un proyecto de prefactibilidad técnico económico para la alternativa que resulte más recomendable de implementar en el corto plazo, de las tres escogidas. .../..

Solicitudes y comunicaciones concernientes a esta descripción de puesto deberán ser enviadas a:

Sección de Contratación de Personal para Proyectos, División de Operaciones Industriales
ONUDI, Centro Internacional de Viena, P.O. Box 300 – A-1400 Viena (Austria).

V.84-92293

En base a este diagnóstico, el experto presentará al Gobierno en su informe los lineamientos generales de un programa para el aprovechamiento más económico de los residuos de madera existentes. Asi mismo, hará recomendaciones en cuanto a los instrumentos económicos y financieros que poner al servicio del sector considerado para facilitar su desarrollo.

Calificaciones: Ingeniero o tecnólogo industrial con experiencia en la investigación desarrollo e implementación de proyectos de conversión energética a partir de residuos forestales.

Idioma: Espanol o inglés con conocimientos básicos de espanol.

Información General: El Instituto Forestal de Chile fue creado en 1960 con la asistencia de la Programa de las Naciones Unidas para el Desarrollo (PNUD/SF). Un elemento del plan de trabajo actual del Instituto es un estudio sobre el uso industrial de los residuos de la madera. El Instituto carece de personal con experiencia en este campo, razón por la cual se le solicitó asistencia al PNUD.

En los ultimos anos, la industria procesadora de la madera chilena se ha desarrollado considerablemente. En 1980, tenía 1948 aserraderos que producían 2.2 millones metros cúbicos de madera cortada. Esta produccion exigió 4.6 mio m^3 de troncos, de los cuales 400,000 m^3 fueron transformados en particulas de madera para la industria de la pulpa y quedaron 2 mio m^3 de residuos, los cuales los aserraderos importantes utilizan de costumbre como combustible para generar electricidad u otras necesidades de energia. Los pequenos aserraderos botan los residuos o los utilizan como combustible doméstico. El Pais tiene 20 aserraderos grandes (producción promedia: 35,000 m^3 de madera cortada en 1980), 6 aserraderos de tamano medio (17,000 m^3) 62 aserraderos (5,500 m^3) y 1410 aserraderos de tamano muy pequeno (750 m^3 anuales de madera cortada).

En las condiciones actuales más de 6 millones de m^3 de residuos forestales son liberados por la explotación de los bosques de coniferas chilenos. Con los programas de gobierno de bonificacion de las plantaciones de pino y con la recuperación de la actividad forestal en el pais, esta cifra puede duplicarse en el coto plazo.
Dadas las condiciones nacionales que inciden en un alto costo de los combustibles derivados del petróleo, aparece altamente interesante el estudio de la conversión energética de los residuos forestales en Chile.

TIMING OF PROJECT ACTIVITIES AND VISITS

The expert's mission started on 2nd December, 1984 and ended on 6th April, 1985, interrupted by an intermediate mission on behalf of the German Government from 11th February, 1985 to 2nd March, 1985. This timing includes an expansion of the expert's mission from originally three months by 15 days.

The expert has been attached to the Instituto Forestal (INFOR) in Santiago de Chile, forming part of a local team. The team consisted of a forest engineer and a chemical engineer as permanent members and of other professionals and students commissioned temporarily.

Interim reports have been sent to UNIDO/Vienna as follows:

20 th December, 1984:[7/]

Interim report on methodology and execution of the programme "Energy Conversion of Forest Residues in Chile";

19th March, 1985:[8/]

Expansion of assignment.

7/ see Annex 3

8/ see Annex 4

Visits and meetings were carried out as follows:

4.12.84 Fritz Werner Industrieausrüstungen,
Geisenheim/Germany

<u>Santiago</u>

5.12. Mr. Juan Antonio Carreño,
Assistant to the Director of INFOR
and Team Member

Mr. César Alarcón,
Assistant to the Director of INFOR
and Team Member

Mrs. Paulina Peña, UNDP/Santiago

6.12. Mr. Patricio Valenzuela,
Director INFOR

Mr. Tomás Reich, UNDP/Santiago

Mr. Ernesto Rendel,
Director PROCHILE

7.12. Conference with Chiefs of Departments
at INFOR

Mr. Julio Segovia,
Chief of Forest Branch, CORFO

Mr. Hush and Mr. Jaime Latorre Alonso,
Project Directors, CONAF/PNUD/FAO
CHI/83/017. Investigación y Desarrollo
de Aréas Silvestres. Zonas áridas y
semi-áridas

13.12.	Technical Advisory Committee of INFOR Col. Hernân Velasquez, President Mr. Ivân Castro, Executive Director CONAF (Forest Service) Mr. Omar Quintanilla, CORFO (Chilean Institute of Productivity) Mr. Patricio Valenzuela, Director INFOR Mr. Juan Antonio Carreño, Assistant to Director INFOR
14.12.	"Energy Talk" at CONAF, by Mr. Ramôn Rosendo, Prof., University of Chile
18.12.	CNE (National Commission of Energy) Mr. Sebastian Bernstein, Executive Secretary Mr. Felippe Cerón, Assistant to E.S. Mr. Oscar Valenzuela, Electricity Branch
19.12.	Asociación de Empresas de Servicio Publico Mr. Rafael Salas Rengifo, Director FAO Regional Office for Latinamerica Mr. Sergio Salcedo, Forest Industries and Energy
20.12.	"Silvicultural Talk", INFOR, by Mr. José Antonio Prado

21.12.	Asociación de Industriales de Madera (ASIMAD) Mr. Tomás Harrison, Director
26.12	CORFO Mr. Luiz Alvarez, Electricity Branch Mr. Edmundo Hernandez, Energy Branch
27.12.	Court y Cia. Ltda. Mr. Gastôn Court de Pedregal Industria de Maderas y Elementos Madel Ltda. Mr. Wolfgang Tauber K. Industria Maderera Fernando Mayer S.A. Mr. Fernando Mayer R. Empresa Industrial Moreno Vial Ltda. Mr. Augustin Moreno Solar Mr. Sebastián Cruz Matte
28.12.	Industria Maderera Klingenberg S.A. Mr. Heinz Klingenberg Mr. Carlos Lundblatt B.
4. 1.	CORFO Mr. Edmundo Hernandez, Energy Branch
7. 1.	Servicio de Cooperación Técnica SERCOTEC/ CORFO Instituto Chileno de Productividad Mr. Maximiliano Gutierrez, S., Chief of Exports Mr. Nemesio Araya R., Supervisor Development Programme

<u>Loncoche</u>

21.1. Muebles Fourcade Soc. Ltda.

Mr. Marcelo Fourcade sen., Director

<u>Valdivia</u>

22.1. Universidad Austral

Mr. Hernán Poblete

Mr. Roberto Kraus

Mr. Manuel Monroy

EMASIL - Industria de Terciados S.A.

Mr. Rolando Figueroa F., Director

Maderas y Sintéticos S.A., MASISA

Mr. Guillermo Michaelis, Director

Mr. Oscar Michaelis F., General Manager

Mr. Guillermo Schwarzenberg B.,
Technical Manager

23.1. Industria Foliadora de Maderas S.A. INFODEMA

Mr. Ricardo Luck, General Manager

<u>Lenca / Puerto Montt</u>

25.1. Industrias Forestales Ltda., INDUFOR

<u>Villarrica</u>

27.1. Muebles Martini Ltda.

Mr. Martini, Technical Director

Concepción

28.1. Universidad BIO-BIO

Mr. Gerhard Stoehr

CIDERE BIO-BIO (Regional Development Corporation)

Mr. Dante Barbato Lopez

Maderas Saenz S.A., MADESAL

Mr. Victor Saenz, Vice President

ARAUCO Forestal Arauco Ltda.

Mr. J. David Campos, Technical Director

Forestal Carampangue S.A.

Mr. Matte, General Manager

29.1. DITECO Ltda.

Mr. Hans P. von Leyser, Director

Laja

29.1. Fabrica de Celulosa Laja

Mr. Fernando Martinez, Chief Department
Process Engineering

Nacimiento

29.1. Industria Forestal S.A./INFORSA

Mr. Eduardo Vial, General Manager

Mr. Hernán Abal, Technical Supervisor

Mulchén

29.1. Aserraderos Mininco S.A.
Mr. Iván Arenas Czischke,
Supervisor of Production

Concepción

30.1. Industria Nacional de Cemento S.A.
Mr. Ulises Palli Bavestrello,
Director Division Bio-Bio

Mr. Jorge Matus Campos,
Chief Studies and Development Branch

Mr. Abraham Poblete Trampe,
Supervisor of Production

Lota

30.1. Soc. Agricola y Forestal Colcura S.A.
Mr. Pedro Urmeneta M.,
Director of Operations

Concepción

30.1. Calefactores Gravitacionales
Mr. José San Juan Quezada

Santiago/Puente Alto

7.2. Cia Manufacturera de Papeles y Cartones S.A.
Mr. Antonio Albarrán Ruiz-Clavijo,
Director Engineering

Mr. Julio de la Fuente Ibar,
Engineering Branch, Thermal Operations

Mr. Ricardo Souter Garcia-Huidobro,
Consultant in Forestry and Forest Industries

7.2. CHIMOLSA
Mr. Patricio Neumann

Santiago

18.3. Universidad Católica de Chile

Mr. Juan Antonio Guzman M.,
Chief Department of Chemical
Engineering

Mr. Rodrigo Jordán,
Assistant Professor

Blatt -1-
KK/AE-1763
20.12.84

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Consul. & Management GmbH
Forst- und Holzwirtschaft

MEMO

For: Mrs. D. Runca, UNIDO/Industrial Operations Division

From: Karl H. Kehr, Expert in Energetical Conversion of Forest Residues (Consultant in Forest and Woodworking Industries)

Project: UC/CHI/83/192 - Assistance to the Instituto Forestal in Industrial Utilization of Woodwaste

Subject: Interim Report on Methodology and Execution of the Programme "Energetical Conversion of Forest Residues in Chile"

1. As agreed during my briefing stay at Vienna, please find enclosed the English Version of my proposal.

2. The respective time schedule has been drafted within the contracted time of three months, giving room for travelling and briefing/debriefing.

3. Nevertheless, the programme is rather packed and delay of works to be executed by the local personnel of support is to be expected due to the imminent Christmas and New Year festivals and being the month of February the "holiday-month" in Chile.

4. Therefore, I personally would like to split the mission from Febr. 11 to March 2, 1985 for 20 days, if such a procedure would be agreed between GTZ and UNIDO. I talked this matter over already with the people of the Forest Institute (INFOR), who fully agreed with my proposal, in order to have these days disposable for pulling up possible delays.

5. Generally, I found good acceptance and cooperation of the Chilean authorities. Specially, there are already available computerized basic data on forest inventory and management on municipal level - also non-computerized energy data - as well as skilled engineers in programming and simulation of computerized models.

6. The programme seems to be quite ambitious, but we agreed that we should start from the point of view of major local

./.

Blatt -2-
KK/AE-   3
20.12.8

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Forst- und Holzwirtschaft

congruency of availability of residues and energetical demand. Thus, we will have to think on mechanical and/or physical/chemical pre-densification only in case of transport of forest residues to other demand centres, since the viability of models and projects seems to be very sensible to transport distances and costs in relation to energetical density and recuperation of primary energy during conversion of transported goods.

Karl H. Kehr
i.A. [signature]

Enclosure copies: (a) Proyecto Energetico (Spanish original)
(b) Energetic Project (English version)

Annex 3

Country: Chile

Project: UC/CHI/83/192

English version from the original in Spanish

ENERGETIC PROJECT

"ENERGETIC CONVERSION OF WOOD RESIDUES"

PROPOSAL FOR THE

METHODOLOGY AND EXECUTION

KARL H. KEHR
UNIDO EXPERT
FOR ENERGETIC PROJECT

ENERGETIC CONVERSION OF WOOD RESIDUES

(INFOR - UNIDO)

A. ACTIVITIES

For the execution of the programme in the available time of three months 1/, the following main activities are suggested:

ACTIVITY 1

Estimate and projection for the potential availability of wood residues 2/

Comments

a) Pine and eucalyptus plantations, established in V to IX Region, will be mainly taken into account. The native forests will be intensively treated in X Region only, due to nearly 90% of the national surface of that forest being in that Region of the country.

b) The estimate for the potential availability will be tried to be undertaken at commune level, in Regions V to IX (170 communes from a total of 285) for the following reasons:

- Basic data are available at communal level of the forestry for these Regions, kept in INFOR and CIREN computation systems.
- 93% of the total pine plantations and 90% of the total area of the country's planted eucalyptus are in these Regions.

1/ See chapter C. Time Schedule
2/ Projection for 15 years (1985 - 1999)

c) The estimate for the potential availability in the other regions will be tried to be undertaken at provincial and regional levels only.

d) Data concerning waste availability will be divided into occurrence, form, volume, yearly distribution, residue cost itself and its transportation cost in relation to distance, energetic density and recovery.

e) The term "Wood Residues" is understood to mean residues originated from either plantations as a consequence of prunings, thinnings and final crops, or of the industrial plants.

Of the wastes originated from silvicultural treatments or final crops, the remaining longer-sized residues will only be taken into account after discounting from the total output of the stands the main forest products as round woods, sawn timber and pulpwood.

In general terms, this study will not consider the minor and fine residues for the energetic utilization, since it is considered as the minimal requirements of nutrient return to the soil.

Furthermore, one must mention that the term residues cannot be rigorously construed in relation to its limitation towards the main forest products, regarding diameter, length and quality of wood. These main forest products can also be destined for energetic conversion provided that they are marketable and that the cost/benefit ratio makes it economical. In the same way, under certain circumstances, the products already mentioned as larger-sized residues could be used as pulpwood according to the same previously mentioned criterias.

It must also be mentioned that the final products from the energetic conversion of biomass include not only fuels but raw materials for the chemical industry in general.

ACTIVITY 2

Estimate and projection for the country's energetic demand

Comments:

a) It refers to all energetics.

b) The potential demand estimate will be tried to be established at commune level in Regions V to IX, since the respective information concerning availability of wood residues for those Regions will also be segregated at commune level (see Activity 1).

c) The estimate concerning the other regions will be established at provincial and regional levels.

d) The existing information about energy will be completed with the Comisión Nacional de Energía, Instituto Forestal, Empresa Nacional de Electricidad S.A., CORFO and other authorities.

e) The information will be divided into occurrence, form, amount, yearly distribution and energetic and transportation costs in relation to distance, energetic density and recovery.

ACTIVITY 3

Determination of local and stational congruence between residue availability and energetic demand

Comments:

The possible incongruence can be solved by transporting the residues from places of larger availability to places of larger demand with or without a larger energetic densification and.

ACTIVITY 4

Assessment of the conversion and energetic densification alternatives for the wood residue for the Chilean case

Comments:

a) Under the term "Chilean Case" the advancement of technology and investment in low and medium terms is referred to, within the economy of scale.

b) Within this assessment, it can be distinguished between the improvement of technologies already existing in the country and the introduction of new technologies.

ACTIVITY 5

Investigation on the way and costs of transportation for the different energy forms from wood residues

Comments:

a) This investigation is limited to the possibilities assessed for the Chilean Case (see Activity 4).

b) It will be basically tried to establish the maximum distance radius economically acceptable for transportation of the residues or its derivates to solve the likely lack of congruence (see Activity 3).

ACTIVITY 6

Elaboration of theoretic models for the energetic conversion of wood residues in the Chilean Case

ACTIVITY 7

Determination of the potential development path ~~methods~~ for the energetic conversion of wood residues in the Chilean Case

ACTIVITY 8

Conclusions and recommendations

Comments:

a) Determination of the three most convenient alternatives of energetic conversion of wood residues in order of priority.

b) Elaboration of a techno-economic pre-feasibility project for the most convenient alternative to be recommended, at short term, from the three alternatives mentioned in point a).

ACTIVITY 9

Preliminary Report

Comments:

After assessing the preliminary report by the Instituto Forestal, the final report will be made.

ACTIVITY 10

Terrain Inspections

Comments:

a) The terrain inspections will be made on two different trips. The first trip will mainly be devoted to inspect the existing technologies of energetic conversion in the country. On the second trip, the necessary information will be collected to establish theoretic models concerning the Chilean Case (Activity 6), after having obtained the information about congruence / incongruence between availability and demand (Activity 3) estimated by Activities 1 and 2 and the basic dates concerning economic study of transportation (Activity 5).

b) To prepare and carry out the terrain inspections, INFOR Regional Division will support this activity.

c) The first trip will include the V Region and Metropolitan Region by means of a vehicle provided by the Institute, and for the X Region by plane.

d) The second trip will include travelling to VI, VII, VIII and IX Regions by plane to Concepción City, and travelling within the area by a vehicle provided by the Institute.

B. <u>SUPPORT UNIT</u>

In order to carry out the programme described, it is necessary to count on an Institute's support unit, whose make-up is suggested to be as follows:

1. To process the basic data at the forestry inventory at commune, province and region levels, already existing in INFOR computation system, it is suggested to have a forestry engineer available for a total time of 3 weeks.

2. Mr. Manuel Cabello, Forestry Engineer, is proposed to simulate, with a total time of 4 weeks, the data processed from the forestry inventory in order to estimate and project (1985 - 1999) the potential availability of wood residues and other simulations concerning energetic demand and to determine the congruence and investigate the transportation costs.

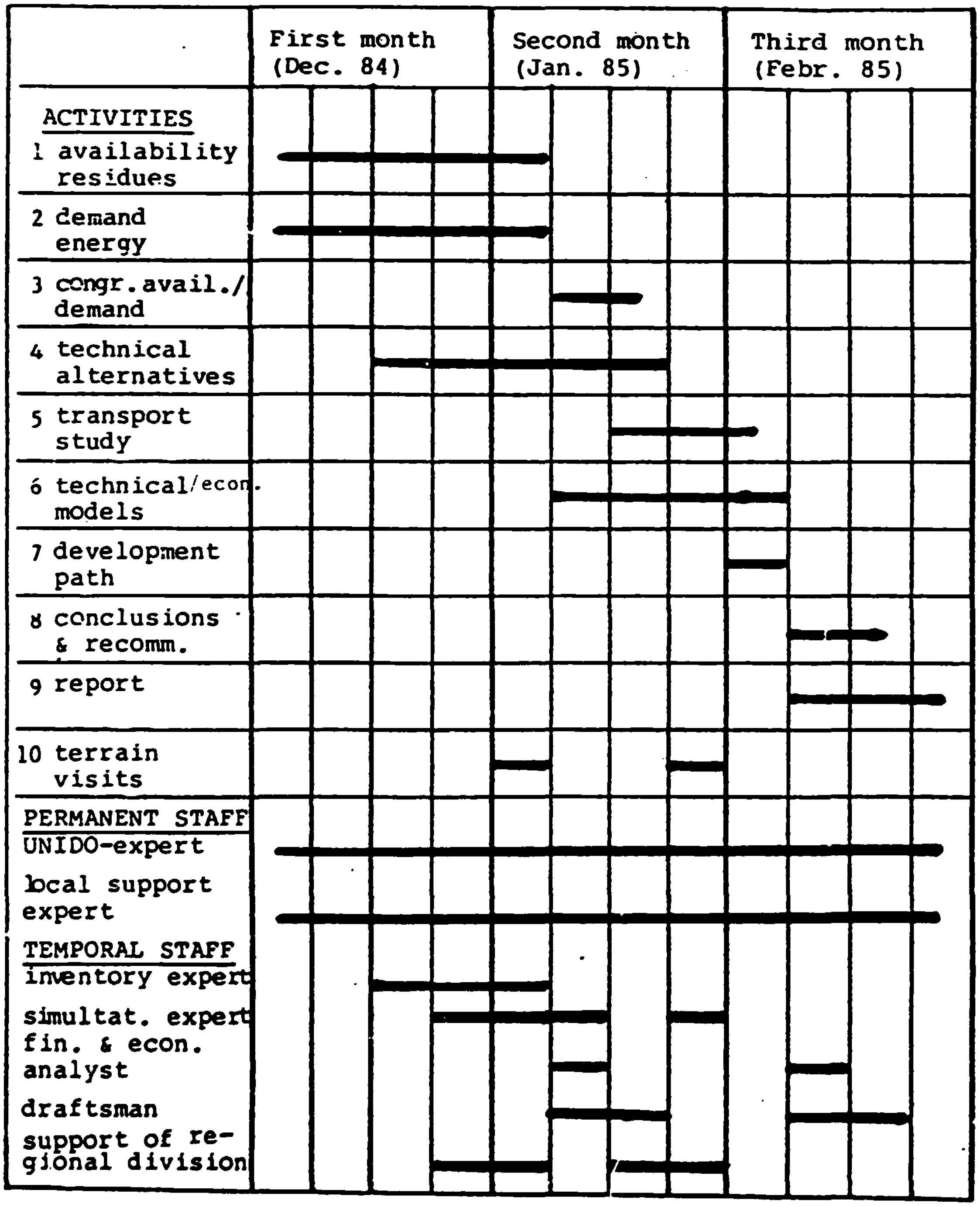
3. A draftsman is needed for the graphical presentation and cartographic work of the data processed, with a total time of 4 weeks.

4) For the study of the economic models of transportation and the techno-economic prefeasibility study, the support of two engineers/week of the INFOR's División Estudios Económicos is required.

5) In order to up-date the respective data, such as product prices, costs, volumes, production, etc. at enterprise level, the support of 4 engineers/week of INFOR's División Regional is required. This support work is required before and during the terrain inspections by the permanent project staff.

C. Time Schedule

The programme will be developed within the time constraint as follows:



KK/KE-924
March 19th, 1985

MEMO

For: Mrs. D. Runca, UNIDO/Industrial Operation Division

From: Karl H. Kehr, Expert in Energetical Conversion of Forest Residues (Consultant in Forest and Woodworking Industries)

Project: UC/CHI/83/192 - Assistance to the Instituto Forestal in Industrial Utilization of Forest Residues

Subject: Expansion of Assignment

1. The Instituto Forestal has asked officially for the expansion of my assignment by 15 days, through the UNDP-office at Santiago (Chile).

2. I would like to underline this application since

   a) works to be executed by local personnel as disponibility of forest residues and energetical demand are delayed, as to be expected (see item 3 of my Memo KK/AE-1763, dated December 20th, 1984);

   b) the recent earthquake put out of order the computer system of the institute and is still causing faults in the assistance of local personnel involved in the project due to home calamities.

3. If you agree to the expansion my Special Service Agreement No. 84-589 should be amended making my contract effective over the period December 2nd, 1984 - April 5th, 1985 (see AMPOGRAM, Ref.: PRU/85/PPRS/APP/JMT, dated January 17th, 1985).

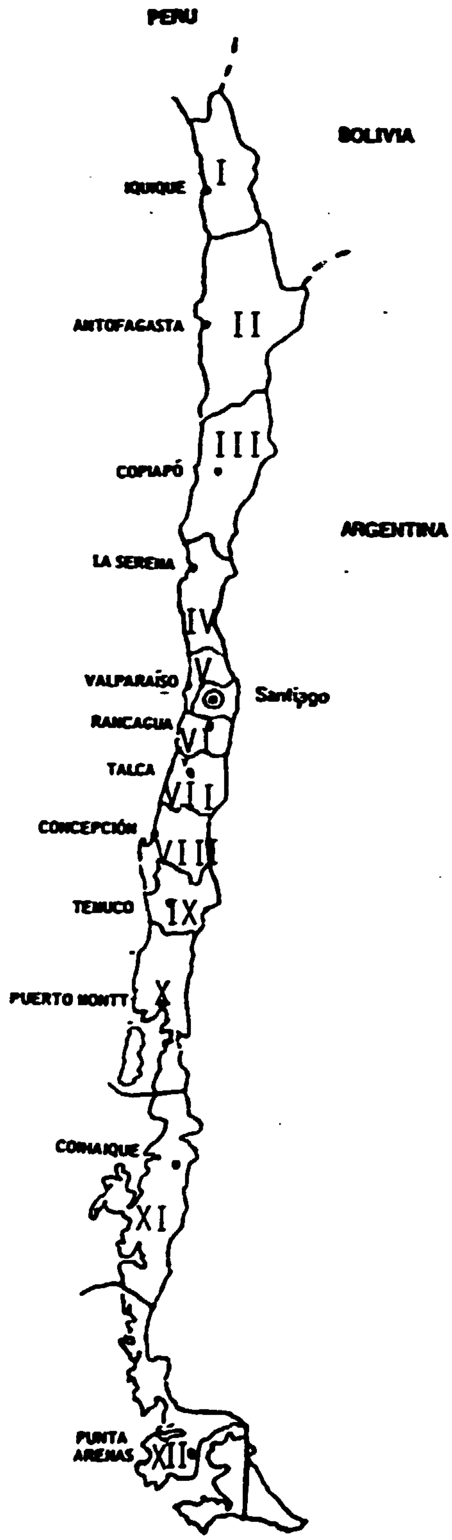
4. I finished the interruption of my assignment from February 11th to March 2nd, 1985, on service for the German Government. Please, arrange DSA-payments taking in account

   a) full rate after returning from Bolivia and Paraguay (see Telex-request UNDP/Santiago 66, dated March 6th, 1985);

   b) eventual expansion of contract.

for Karl H. Kehr

MAP OF CHILE



REGIONS I - XII

Provinces

IQUIQUE
1 Arica(Arica)
2 Iquique(Iquique)

ANTOFAGASTA
3 Tocopilla(Tocopilla)
4 El Loa(Calama)
5 Antofagasta(Antofagasta)

COPIAPÓ
6 Chañaral(Chañaral)
7 Copiapó(Copiapó)
8 Huasco(Vallenar)

LA SERENA
9 Elqui(La Serena)
10 Limarí(Ovalle)
11 Choapa(Illapel)

VALPARAÍSO
12 Petorca(La Ligua)
13 San Felipe(San Felipe)
14 Los Andes(Los Andes)
15 Quillota(Quillota)
16 Valparaíso(Valparaíso)
17 San Antonio(San Antonio)
18 Isla de Pascua(Hanga Roa)

RANCAGUA
19 Cachapoal(Rancagua)
20 Colchagua(San Fernando)

TALCA
21 Curicó(Curicó)
22 Talca(Talca)
23 Linares(Linares)

CONCEPCIÓN
24 Ñuble(Chillán)
25 Concepción(Concepción)
26 Bíobío(Los Ángeles)
27 Arauco(Lebu)

TEMUCO
28 Malleco(Angol)
29 Cautín(Temuco)

PUERTO MONTT
30 Valdivia(Valdivia)
31 Osorno(Osorno)
32 Llanquihue(Puerto Montt)

COIHAIQUE
33 Chiloé(Castro)
34 Aysén(Puerto Aysén)
35 General Carrera(Chile Chico)
36 Capitán Prat(Cochrane)

PUNTA ARENAS
37 Ultima Esperanza(Puerto Natales)
38 Magallanes(Punta Arenas)
39 Tierra del Fuego(Porvenir)
40 Antártica Chilena(Puerto Williams)

0 200 400 km