REPORT OF THE ENVIRONMENTAL SCIENCE COMMITTEE APPOINTED BY CONICYT TO DEVELOP A COUNTRY PROFILE TOWARD ESTABLISHING RESEARCH COLLABORATIVE TIES WITH THE EUROPEAN UNION, THROUGH PARTICIPATION IN INTEGRATIVE PROJECTS (IP) AND CENTERS OF EXCELLENCE NETWORKS (NW)

Warning: This text does not carry accents or tildes

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Executive Summary: With short notice, CONICYT requested that Chilean scientists express their interest in establishing meaningful collaborative ties with EU peers. A flood of individual researcher profiles ensued. Of these, 169 fit Strategic Area VI, that is, "Sustainable Development, Global Change and Ecosystems." Of that total, 27 corresponded to Sustainable Energy & Water, 7 to Sustainable Transportation, and the remaining 135 to Global Change & Ecosystems. All of these indiviual profiles may be downloaded from CONICYT's web page (http://sbch.conicyt.cl/). In addition, six National Centers (made up from 10 to 30 researchers) submitted their respective profiles, indicating which Strategic Areas they addressed as Centers (see attachments). They thus abstained from presentating individual researcher profiles such as the 169 already mentioned, but all the information necessary to identify specific researchers, and their EU conctacts, is contained in the enclosed Centers' profiles.

1. CHILE'S STATE OF THE ART IN ENVIRONMENTAL SCIENCE

Environmental Science is not recognized as such in Chile. Environmental scientists carry on their research and teaching activities in more widely recognized fields such as Biological, Earth, Engineering, and Marine Sciences. For this reason, it is difficult to determine how many research projects have been, or are being awarded, to Environmental Science as such.

In alphabetical order, Agronomists, Biologists, Chemists, Ecologists, Economists, Engineers, Mathematicians, and Physicists make the bulk of what may be called environmental scientists in Chile, but they rarely work in concert or approach a common problem in an integrated fashion. According to Armesto et al. in "Chile-Ciencia 2000," (http://www.ciencia.cl/ChileCiencia2000/areas/ciencias-amb.rtf) there are about 200 environmental scientists in the country. They are concentrated in just of few of the 80 universities currently recognized (in alphabetical order): Pontificia Universidad Catolica de Chile, Universidad Austral, Universidad de Chile, Universidad de Concepcion, Universidad de La Serena, Universidad de La Frontera, Universidad de Los Lagos, Universidad de Santiago, Universidad de Valparaiso, Universidad Tecnica Federico Santa Maria. Historically (over the last 20 years), environmental scientists have been funded by the Fondecyt program of Conicyt, which is the main source of financial support for Chilean scientists.

Most of the active environmental scientists are grouped into units of different sizes and autonomies; from 2-3 team laboratories, to 10-15 research nuclei, to ca. 30-strong research centers. Because of the tendency to fragmentation and specialization, the Chilean government has actively promoted the largest groupings through two types of initiatives: The Millennium Scientific Initiative (sponsored by the Ministry of Planning and Cooperation) and the Research Priority Areas Program (sponsored by the Ministry of Education through Conicyt). These governmental initiatives have awarded funding to those groups recognized by their peers not only as scientifically productive but also committed to graduate-level training of future generations of scientists.

Apart from numerous laboratories based in different universities of the country, there are two small centers funded by the Millennium Scientific Initiative and three larger ones funded by the Research Priority Areas Program. They are, respectively: (a) Millennium Center for Advanced Studies in Ecology and Research on Biodiversity (MCEB), (b) Scientific Nucleus "Forests ecosystemic services to aquatic systems under climatic fluctuations" (FORECOS), (c) Center for Oceanographic Research in the southeastern Pacific (COPAS), (d) Center for Advanced Studies in Ecology and Biodiversity (CASEB). (e) Center of Applied Mathematics for Informatics and Modeling (CMM). In addition, there are two other centers: (f) Center for Advanced Studies on Arid Zones (CEAZA), funded by CONICYT, and (g) Center for Environmental Policy and Studies (CEPA) at the Pontificia Universidad Catolica de Chile, with funding from several sources.

It should be noted that currently there are no environmental science centers in Chile that integrate the work of physical/biological scientists with that of social/economic scientists.

2. MAIN RESEARCH LINES IN SUSTAINABLE ENERGY SYSTEMS

This part of the report will dwell only in what is presently being conducted as research and development efforts in sustainable energy in Chile.

2.1 Overview

Chile has an exceptional supply of sustainable energy sources. In the northern part of the country, there is ample geothermal, solar and wind power. In fact, the first large scale solar water still that existed in the world was built in 1872 near Antofagasta. It operated continuously from that year up to near 1912, producing over 4.000 liters of fresh water per day. In the mid part of Chile, besides abundant hydropower, there are abundant untapped geothermal reservoirs as well as significant wind and solar power. In the southern part of Chile, there are important untapped hydropower, geothermal and wind power sources, as well as abundant biomass of significant energy potential (mostly sawdust and wood production residues). But during the last decades, energy supply has been met mostly with traditional hydropower sources (hydro accounts for around 60 to 70% of commercial electric energy production in the two main interconnected systems, but only around 40% of installed power) as well as fossil fuels (mainly natural gas from Argentina). Since presently we do not have significant local oil or gas supplies, over 97% of fossil fuel needs is met by imports.

The Chilean government established the Comisión Nacional de Energía (CNE, National Energy Commission) in 1982 to promote a novel electricity market structure based on a Pool with Competition at the Generation Level, which has been extended around the world. For this reason, its role has been mainly devoted to the electrical sector, and it does not have significant programs either in sustainable energy use or energy efficiency programs. During the past decades, most of the efforts conducted as regards sustainable energy have been small scale, originating either in universities or from private enterprises. Presently there is 1.8 MW of installed power in a single wind project in southern Chile (three 660 kW Vestas Turbines); several hundred domestic PV systems in the range of 40 to 100 W nominal power for isolated rural houses; larger scale use of PV power for telecommunications (microwave links as well as rural phones and highway signaling) and small solar thermal systems for domestic hot water production.

2.2 Specific Energy Sources

2.2.1 Geothermal Energy

Systematic geothermal exploration in Chile started in 1968 and was restricted to its northernmost part. This project was administrated by the Corporación de Fomento de la Producción together with the United Nations Development Program (CORFO/UNDP). This exploration program has included the geological and geochemical reconnaissance of many hot spring areas and detailed geological, geophysical and geochemical surveys in two selected areas. In these areas exploratory and production wells have been drilled and feasibility studies for a 20 MW power plant were made at El Tatio geothermal field. In order to investigate the feasibility of obtaining fresh water as a byproduct of electricity generation, a pilot plant for geothermal fluid desalination was put into operation at El Tatio from 1975 to 1976. Thus, it was possible to demonstrate that 10 liters per second of fresh water could be recovered per each MW power potential. Some tested high temperature geothermal systems together with geological, geochemical and volcanological studies in several thermal areas of the country, allow the assessment of the geothermal potential for electricity generation of some 16.000 MW.

The Geology Department of the University of Chile has been doing basic research over a number of years on the possibilities of geothermal energy in the country. Presently it is carrying out a 4-year FONDEF/CONICYT research project on the geothermal resources of Central and South Chile, in collaboration with the Empresa Nacional del Petróleo (ENAP), and institutions in Italy, Germany and New Zealand. A law that governs the regulatory aspects of geothermal use in Chile was passed by the Chilean Congress in the year 2000. In addition, the Electrical Engineering Department of the University of Chile is undertaking a join research project with CNE to identify and evaluate possible technical and economical entrance barriers for renewable energy sources RES (including geothermal and wind sources) into the electricity Chilean market.

2.2.2 Solar Energy

Solar projects conducted in Chile have been mostly small scale. There are a few manufacturers of thermal solar systems that can supply domestic hot water as well as design and installation of small-scale PV systems.

Research efforts have been mostly conducted at the university level. In the Universidad de Chile there is a group that has been devoted to solar drying, cooking, as well as passive thermal systems. There are also significant groups in the Universidad Tecnica Federico Santa María (Valparaíso), Universidad de Tarapacá (Arica), and Universidad Católica del Norte (Antofagasta). The projects that have been recently conducted have been mostly coordinated through the CYTED Program (Ciencia y Tecnología para El Desarrollo) in which all these groups participate with other Latin American Countries as well as with research groups in Spain and Portugal.

For November 2003, the Universidad Catolica de Chile is organizing, with a group from the Universidad de Chile, Universidad Central, and the Ministry of Housing, the PLEA (Passive and Low Energy Architecture) 2003 Congress. This event, which is held every two years, was last held in Toulouse, France.

2.2.3 Wind Power

Research in wind power utilization has also been conducted for over twenty years, though mostly restricted to low-power systems. The Universidad de Chile, with the collaboration of the CNE (Comisión Nacional de Energía) and CORFO (Corporación de Fomento) conducted a general wind-power assessment study in 1992, which established general methodological guidelines as well as estimation of wind power potential in the country.

On a more specific level, detailed wind energy measurements have been conducted near Coyaique (Aysén) by CORFO from 1991-1992 and by Wireless Energy (a private company) more recently. On the basis of these studies, three 660 kW wind turbines were installed in late 2001 and have operated successfully since that date. A detailed wind-energy analysis is currently being done in the northern part of the country (near Chuquicamata) by Wireless Energy, but due to excessive thermal power generation capacity in this region, it is not likely that any large-scale system will be installed in the near future.

At the university level, besides the above-referred work by the Universidad de Chile, there have been significant contributions by groups in Universidad de Tarapacá (Arica) on hybrid wind PV systems; Universidad de La Serena on small scale electric wind pumping systems; Universidad Santa María on the utilization of wind energy for isolated island electric power generation and Universidad de Magallanes on wind power generation in the extreme south of the country.

2.2.4 Biomass

The forest industry is an important industrial sector in Chile. Forest products include pulp for cellulose production as well as largely unprocessed wood products. This industry produces a significant amount of biomass residues, which can be easily used for energy production. In the case of the cellulose industry, all modern plants include efficient energy use, so the plants not only meet their process heating demands by steam produced within the plant, but also cover 100% of their electrical energy needs and normally produce a significant electrical energy surplus. This surplus could be increased if the laws that govern electrical production and utilization were more favorable towards the small-scale producers.

The forest industry also produces significant biomass waste. A small company was started about ten years ago ("Energía Verde," Green Energy) with modular 8 MW thermal energy systems for producing electrical energy from biomass. There are about six of these plants in operation, but no more have been built due to lack of proper incentives.

Within the university system, significant work has been done on biomass production from algae, both for the purification of waste water as well as for energy production.

2.2.5 Efficient Energy Use

This method is widely acknowledged to usually be the most cost-effective method to better use energy. This includes both energy efficiency analysis (both first and second law analysis) as well as energy cogeneration systems. In the case of the Universidad de Chile, the PRIEN program (Programa de Investigación en Energía) has over ten years of experience in efficient energy use, as well as studies conducted to help the government sector have better energy policies. This program conducts work in close association with the GTZ program as well as the Canadian development agency.

The Electrical Engineering Department of the University of Chile has been working in this field for more than 20 years in the following areas: methods and techniques for security and stability operation of future flexible distribution systems with significant RES, combined heat and power, development in regulation frameworks, Open Access requirement, and tariff model of transmission systems, planning of power systems in competitive environments, models and coexistence of different market designs, and power quality.

2.3. Sustainable Energy and Chile

Sustainable energy has an enormous potential in Chile. This is true for almost all energy types. In the case of electric power generation, the sources with the highest short-term application potential are geothermal and wind energy. Photovoltaics has a large development niche, especially for power generation for small productive projects isolated from the power grid as well as basic electricity coverage for isolated housing.

In the domestic sector, there is a large untapped potential both in efficient energy use as well as in low grade heat production from solar energy. In the industrial sector, the largest short term applications lie in efficient energy use as well as schemes such as cogeneration, which as rarely been applied here in Chile.

The research sector has ties both to other groups in the country, as well as groups in Europe and other Latin American countries. We feel that our most serious obstacle has been the lack of long-term sustainable energy policies from the government. Energy policies have been price-driven for the last twenty years, and have simply ignored the fact that fossil fuel supplies are almost nonexistent in our country, and international supplies are subject to great volatility as regards price and availability.

The following 26 individual researchers' profiles fit this topic: Arias (IP), Baeza (IP and NW), Barahona (IP), Bustamante (IP), Concha (IP and NW), Debels (IP and NW), Espinoza (IP), Fernandez (IP), Fissore (IP and NW), Garces (IP), Garcia (IP), Gordon (IP),

Helle (IP), Kunstmann (IP), Lahsen (IP and NW), Mansilla (IP), Mardones (IP), Merino (IP), Olcay (IP), Oyarzo (IP), Palma (IP and NW), Pizarro (IP), Rodriguez (NW), Roth (IP and NW), Rozas (IP and NW), Rudnik (IP), Vargas (IP and NW).

3. MAIN RESEARCH LINES IN SUSTAINABLE SURFACE TRANSPORT

Chile is already well-known for its top-rank research in some transport related fields, mainly areas related to the economics of time assignment and the value of travel-related time, travel demand data collection methods, transport demand forecasting, complex multi-mode-multiple-users urban transport networks, and transport-supply economic analysis. The biannual Chilean Congress of Transport Engineering, now in its 11th version, is a forum attended by all top-Chilean researchers as well as many foreign experts in the field. In addition, from the mid-nineties several researchers have successfully engaged in valuation of transport-related externalities such as accidents, atmospheric pollution and noise, as well as studies on environmental and transport related risk perception. It should also be noted that transport national agencies are recognized for the high quality profile of their professionals and the modelling tools used in travel demand forecasting and social project evaluation.

Most transport research in the country has been conducted at the Department of Transport Engineering of the Pontificia Universidad Catolica de Chile (PUC) and at the Department of Civil Engineering, Universidad de Chile (UCh), but the Departments of Industrial Engineering at both PUC and UCh have also produced some work in these areas. The research work in this case has mostly been funded by CONICYT and has received the informal collaboration of well-known specialists from Europe.

Due to the high external costs of transport activities, mainly in metropolitan areas such as the Great Santiago conurbation, there is a shift in transport demand analysis both at the academic and governmental levels. The importance of focusing on all relevant dimensions of transport projects, including external impacts, is increasingly being recognised. In the sense of this initiative, the following two lines of research are worth noting.

3.1 Congestion effects and value of time

Congestion is in the increase in urban areas of developing countries such as Chile, as car ownership is increasing rapidly (it doubled in the last decade) fueled by the growth in per capita income. Congestion brings about larger delays and is at the heart of several other traffic related problems such as accidents and pollution (see 3.2. below). The social evaluation of transport projects, in particular infrastructure improvements but also demand management policies such as road pricing, require the existence of appropriate monetary valuations being attached to time savings (that constitute typically over 85% of the benefits of such projects). Included here are individual and collective research programs carried out, mainly with governmental support, by the Departments of Transport Engineering at PUC and the Department of Civil Engineering at UCh.

3.2 Social valuation of transport externalities

One of the main social hazards of increasingly congested metropolis of developing countries are road fatalities and environmental pollution (including noise). These items are typically not considered directly in the social evaluation of improvement projects, and methodologies for its appropriate valuation are considered a state-of the art topic even in developed nations. The research work in this case is funded by CONICYT (but has counted with the informal collaboration of well-known specialists from Europe) and has been producing state-of-the art results (some of which are currently being replicated by some European initiatives).

The following seven individual researchers' profiles fit this general research area: Cifuentes (IP), Coeymans (IP), Garrido (IP), Jara (NW), O'Ryan (IP and NW), Ortuzar (IP), Reinke (IP and NW). In addition, Donoso (PUC), Galetovic (UCh), Martínez (UCh), Munizaga (UCh), Rizzi (UCh) and Sanchez (PUC) work in this area, although they did not submit their profiles.

4. MAIN RESEARCH LINES IN GLOBAL CHANGE AND ECOSYSTEMS

Below, using the stated research priorities of the European Union, we outline the main research lines being conducted in Chile that could benefit from partnerships with European scientists.

4.1 Greenhouse gas emissions, atmospheric pollutants, and inter-annual climatic variability (ENSO)

Included here are individual and collective research lines/programs aimed at understanding: changes in carbon and nitrogen cycles; sources and sinks of greenhouse gases and atmospheric pollutants; effects on climate dynamics and on ocean and atmospheric chemistry; stratospheric ozone levels and ultraviolet radiation; global climatic change and impacts; associated phenomena (e.g. El Niño, changes in sea level and ocean circulation); and mitigation and adaptation strategies.

The following 15 individual researchers' profiles fit this priority: Barra (IP and NW), Casanova (IP), Cereceda (IP and NW), Conca (IP), Cordaro (IP), Delgado (NW), Fiebig (IP), Gallardo (IP and NW), Godoi (IP and NW), Gramsch (IP), Jorquera (NW), O'Ryan (IP), Olivares (IP), Rivas (NW), Schneider (IP).

The following four Centers investigate these topics: CASEB, CMM, COPAS, FORECOS.

4.2 Water cycle, including soil-related aspects

Included here are individual and collective research lines/programs aimed at understanding: impact of climate change on components of the hydrological cycle; on land/ocean/atmosphere interactions; on groundwater/surface water distribution; on freshwater and wetland ecosystems; on soil functioning and water quality; assessment of vulnerability of water/soil systems to land use; soil management strategies; scenarios of water demand and availability.

The following 25 individual researchers' profiles fit this priority: Aguilera (IP), Araya (IP), Bornhardt (IP and NW), Briceno (IP and NW), Collao (IP), Cordova (IP), Fiore (IP), Ginocchio (NW), Iroume (NW), Jordan (IP), Kelm (NW), Kirstein (IP), Machuca (IP), Martinez-Castillo (IP), Martinez-Poblete (IP), Munoz (IP), Pena (IP and NW), Pererira (IP), Pesenti (IP), Pizarro (IP and NW), Rivera (IP), Salazar (IP and NW), Silva (IP), Squeo (IP), Stegen (IP and NW).

The following three Centers investigate these topics: CASEB, CEAZA, FORECOS.

4.3 Biodiversity and ecosystems

Included here are individual and collective research lines/programs aimed at understanding: changes in biodiversity, structure, function, and dynamics of ecosystems and their process-related services; relationships between society, economy, biodiversity and habitats; drivers affecting ecosystems' functioning and biodiversity; risk assessment, management, conservation, mitigation and rehabilitation options and planning in terrestrial and marine ecosystems.

The following 27 individual researchers' profiles fit this priority: Avendano (IP), Bozinovic (IP and NW), Carrasco (NW), Castro (IP), Cavieres (IP), Cepeda (IP), Fernandez (IP), Garbarino (IP), Gomez (IP), Hauenstein (IP), Herve (IP), Jorquera (IP), Luna (IP), Marin (IP), Moenne (NW), Parra (IP and NW), Ramirez (IP), Rau (IP), Riquelme (IP), Rosenfeld (IP and NW), Sielfeld (IP), Simonetti (NW), Thiel (NW), Urrutia (IP), Vila (IP and NW), Villarroel (IP), Zuleta (IP).

The following five Centers investigate these topics: CASEB, CEAZA, COPAS, FORECOS, MCEB.

4.4 Mechanisms of desertification and natural disasters

Included here are individual and collective research lines/programs aimed at: understanding large scale land/soil degradation and desertification; long term forecasting of hydro-geological hazards; natural hazard monitoring, mapping and management strategies; improved disaster preparedness and mitigation.

The following six individual researchers' profiles fit this priority: Arancio (IP), Cardemil (IP), Fiebing (NW), Garces (IP), Gutierrez-Camus (IP), Salvatierra (IP).

The following three Centers investigate these topics: CASEB, CEAZA, MCEB.

4.5 Strategies for sustainable land management, including coastal zones, agriculture, aquaculture, and forests

Included here are individual and collective research lines/programs aimed at: developing tools for integrated management of coastal zones (ICZM); evaluation of positive and negative externalities under different production systems for agriculture and forestry; development of strategies for sustainable forest management; strategies/concepts for sustainable management and multipurpose utilization of forest, agriculture and aquaculture

resources; cost-efficiency of new environmentally-friendly processes and recycling technologies within the integrated forestry/wood chain.

The following 53 individual researchers' profiles fit this priority: Abarca (IP), Acevedo (IP and NW), Alfaro (IP), Antezana (IP and NW), Astorga (IP), Belmar (NW), Botti (IP), Bravo (IP), Buschmann (IP), Cespedes (IP), Corcuera (IP), Ellies (IP and NW), Fadda (IP and NW), Figueroa Dante (IP), Figueroa-Benavides (IP and NW), Gallardo (IP), Galvez (IP), Gutierrez-Moya (IP), Herve (NW), Hidalgo (NW), Ipinza (IP and NW), Kausel (IP), Mancilla (IP), Manzanarez (IP), Montecino (NW), Mora (IP), Moreno (IP), Navarro (IP), Ojeda (IP), Pena (IP and NW), Peredo (IP), Pesenti (IP), Pinto (IP), Rebolledo (NW), Reyes-Serrano (IP), Reyes-Velasquez (IP), Rojas-Hernandez (IP and NW), Romero (NW), Salamanca (IP), Schlotfeldt (IP), Sepulveda-Becker (NW), Sepulveda-Chavera (NW), Skewes (IP), Toledo (IP), Torres (IP), Tosti-Croce (IP and NW), Verdugo (IP), Vidal (IP), Wiertz (IP and NW), Zamora (IP and NW), Zamudio (IP and NW), Zavala (NW), Zaviezo (IP).

The following four Centers investigate these topics: CASEB, CEAZA, FORECOS, MCEB.

4.6 Operational forecasting and modeling, including global climate change observation systems

Included here are individual and collective research lines/programs aimed at mid- to long-term monitoring of marine, terrestrial and atmospheric parameters necessary for the assessment of global change research and management strategies, and identification of extreme events; large observing/monitoring/surveying/operational forecasting/modeling networks.

The following single individual researcher' profile fits this priority: Lagos (NW).

The following six Centers investigate these topics: CASEB, CEAZA, CMM, COPAS, FORECOS, MCEB.

4.7 Complementary research, including methods for risk assessment and for appraising environmental quality

Santiago, the capital of Chile, suffers from very high air pollution levels. Models to assess and value the impacts of air pollution on human health have been developed and tested. Research on the impacts of air pollution on human health, ranging from premature mortality effects to physiological changes, has been carried out. Also, valuation of some health effects, most notably premature mortality, has also been conducted using different techniques. This body of basic research has made it possible to conduct a full assessment of different policy options to reduce air pollution levels in Santiago. Given that local pollutant emissions and greenhouse gas (GHG) emissions have in many cases common causes, the study of the consequences of controlling simultaneously both types of pollution presents a natural advantage with respect to trying to control each. Given that developing countries do not have a commitment yet to reduce greenhouse gas emissions, the study of the link between GHGs and local air pollutants and their effects is important in order to incorporate them into the policy options considered by the authority. Research in this area has been

very active in the Pontificia Universidad Catolica de Chile (PUC), and has received broad international attention.

The unique features of Chile, that is, bounded to the west by the Pacific Ocean and to the East by the Andes Mountains, and being a slender country (average E-W width near 170 km) make the steep sloping of the land surface, and the associated coupling of heat and momentum exchange a challenging problem from the geophysical standpoint. One critical issue is to understand the onset and fate of the severe air pollution episodes that have impacted Central Chile with huge PM_{10} episodes, reaching pollution levels as high as 820 $\mu g/m^3$ (hourly value) at Santiago. In addition, the southern part of Chile is now becoming increasingly polluted by use of wood stoves for heating in fall and winter seasons, with ambient particulate matter levels similar to those recorded at Santiago; since the population potentially exposed is near 2 million people, the issue is worth of being pursued as well.

Research on synoptic-scale flow over the Andes Mountains is being carried out by the Universidad de Chile (Geophysics Dept.) with the support of CONICYT. The atmospheric motion at regional scale (and its interaction with regional transport of pollutants in central and northern Chile) has been studied by Chilean researchers (CMM) supported by the Swedish Hydrological and Meteorological Institute (SMHI). At the mesoscale-level, research on air quality dynamics in the Greater Santiago Metro Area is being developed at Universidad de Chile and PUC by researchers supported by the National Commision for the Environment (CONAMA), along with researchers from Imperial College (UK) and U. of Koln (Germany), supported by The British Council and GTZ, respectively. A state-of-the-science understanding of these issues is a key step to obtain quantitative estimates of the environmental benefits of lower emissions in Chile's most populated basins, that is, a result critical to assess sustainable growth along the country. Work along these lines is going on, with several papers already published in peer-reviewed international journals.

The following eight individual researcher's profiles fit this priority: Blamey (IP and NW), Guzman (IP), Novoa (IP), Ortega (IP and NW), Pizarro (IP), Rojas-Rudolph (IP), Sommerhoff (IP), Varas (IP). In addition, Cifuentes (PUC), Gallardo (UCh), Garreaud (UCh), Jorquera (PUC), Ortuzar (PUC), and Sanchez (PUC) work in this area.

The following Centers investigate these topics: CEPA, CMM.

5. POTENTIAL FOR CHILEAN COLLABORATION WITH THE EUROPEAN UNION

5.1 With regard to Sustainable Energy Systems

Chile has a great amount of renewable energy sources: in the northern part of the country there is a large potential of geothermal, solar and wind power; in the central snd southern part of Chile, besides abundant hydropower, there are untapped geothermal reservoirs as well as significant wind and solar power; in the southernmost part of the country, there are important non-exploited hydropower, geothermal and wind power sources, as well as abundant biomass of great energy potential (mostly sawdust and wood production residues).

Global change, energy security, sustainable transport, sustainable management of Chilean natural resources, and their interaction with human activities should motivate many research projects. The activities to be carried out within this collaboration proposal aim at strengthening the scientific and technological capacities needed for Chile to be able to implement a sustainable development model in the short and the long term. This proposal should integrate social, economic and environmental dimensions, as well as making a significant contribution to international efforts to mitigate or even to reverse current adverse trends, to understand and control global change and preserve the equilibrium of ecosystems.

Strategic objectives address the reduction of greenhouse gases and pollutant emissions, the security of energy supply and the increased use of renewable energy sources (geothermal, wind, solar, biomass). Achieving these objectives in the short term requires large-scale research efforts to encourage the development and utilization of these energies and to help promote changes in energy demand patterns and consumption behavior by improving energy efficiency and integrating renewable energy into the energy system. The long-term implementation of sustainable development requires also an important RTD effort to assure the economically attractive availability of energy, and to overcome the potential barriers to adoption of renewable energy sources.

Competition in the electric sector is an important issue at a worldwide level and currently there are many market paradigms under study. Chile has more than 20 years of experience in this field while several countries of the EU are now in a restructuring process that propose new requirements and challenges, particularly for the integration of renewable energy sources in the markets. To carry out this objective it is required an important effort in the investigation of both, technical and economic aspects. These aspects include a wide spectrum of research topics related with power electric systems, which may be summarized as follows: (a) Development in regulation frameworks, (b) Distributed Generation, (c) Combined Heat and Power, (d) Open access requirement, and tariff model of transmission systems, (e) Planning of power systems in competitive environments, (f) Models and coexistence of markets: physical bilateral, financial bilateral and pool structures, and (g) Power Quality.

5.2 With regard to Sustainable Surface Transport

Santiago ranks among the most polluted cities in Latin America. Most of the greenhouse gases and atmospheric pollutants are generated by the urban transport activity. Recently, the Government has been studying a new system of regulations/incentives to rationalize the public transport sector in order to control the negative externalities. The result of the many studies commissioned by the Government in this field will be materialized in a bid system where competitors will propose to operate a corridor with a given capacity and vehicular technology for a certain fare. The implementation of the new system will allow to measure the actual effectiveness of the proposed policy from many multidisciplinary angles (technical, economical, social, etc.) and correct or emphasize specific aspects of the public transport operation. The task of measuring state variables ex-ante and ex-post for this “real-life experiment” is a unique opportunity that should not be disregarded to facilitate the collection of valuable research data. Multinational teams should benefit from this opportunity.

There is a great deal of expertise in the automatic measurement of traffic flow in about 300 points in Santiago, along with at least five fixed stations to measure air quality in different locations, plus several mobile stations for atmospheric diagnosis. Therefore, these data have been collected already and the instruments are prepared to measure the changes imposed for the new organization of the public transport. The Chilean researchers in transport and environmental engineering have been working theoretically and practically with models that need this type of data to be calibrated. Joint efforts with European researchers would enable the synergy needed to take a significant step forward in terms of research productivity (basically high level publications and formation of new human resources in this area).

Two other areas where collaboration may be fruitful is in the valuation of transport externalities and in understanding the relationship that lies behind individual preferences for the car in order to build sustainable public transport systems. With respect to the first issue, a good deal of research has already been done en Chile in the valuation of road accidents, noise and air pollution, which was welcomed by the academic community. Even more, with respect to road accidents valuation, the methodology is being replicated by a Dutch study. It is believed that the final goal of a research program on environmental valuation should be to formulate models to be included in transport project appraisal since the conception of a new scheme, and not as an add-on. This would turn transport project appraisal more robust and credible, contributing to better and more transparent public decision-making.

With respect to the second issue, a better understanding of travel time, reliability, safety, comfort, and price are necessary. Observed modal split in urban settings do not seem to move into the right direction regarding system-wide quality of life. In Europe, as in other parts of the world, there is a need for rebalancing transport modes to assure transport of passengers, taking into account transport demand. This explicit objective requires widening the scope of travel demand models in order to incorporate the joint choice of activities (work, leisure, travel, others). This should be specifically oriented to understand the motives behind the choice of modes that induce congestion (car), to design adequate integrated policies regarding scheduled public transport, including pricing and coordination, and to appraise correctly system wide improvements in regions were both leisure time and work productivity are increasingly important. This poses an important methodological challenge: although travel time savings account for the largest proportion of benefits in the appraisal of transport projects, travel demand is still viewed in isolation regarding time assigned to both mandatory and discretionary activities. Transport models do not include presently the capability to understand such a relation that lies behind individual preferences for the car. Building sustainable public transport systems require new integrated approaches (which we are working on) that require detailed information on time assignment that is presently being collected in many European cities. A network of excellence would induce synergy that will greatly improve the quality of research.

It should be noted that there is already ongoing collaboration between the Department of Transport Engineering at PUC and the Universitá di Cagliari, Italy, the University of Cardiff, UK, the Universidades de La Laguna and Las Palmas de Gran Canaria, Spain, the Universidade de Lisboa (Portugal), and the Transport Economics Institute, Norway. There is also collaboration between the Department of Civil Engineering at UCh and the Institut

fur Verkehrsplanung, ETH, Switzerland, Universidad de Cantabria, Spain and the University of Leeds, UK.

5.3 With regard to Global Change and Ecosystems

One interesting option for a large integrated proposal is to combine the efforts and resources of individuals and centers engaged on long-term monitoring and assessment of terrestrial/aquatic ecosystem functions and services, including biodiversity indicators of these functions, for representative ecosystems in regions of different sensitivity to global change. The latitudinal extent and diversity of ecosystems in Chile, from dry deserts to wet forests and from coastal lowlands to high alpine environments, provide an opportunity to use the country as a "sensor" of global change in subtropical latitudes of the southern hemisphere.

Climate systems are primarily controlled by the southeastern Pacific anticyclone, which varies in strength at several temporal scales, thus regulating the flow of westerly winds that bring rainfall to central and southern Chile. Hence, terrestrial and marine ecosystems and their organisms are strongly sensitive to decadal or interannual variability in the earth-ocean-atmosphere system over the southern Pacific. A network of research sites providing facilities for inter-disciplinary assessment of physical-biotic-human drivers of global change at different latitudes along Chile should provide useful information for improving Global Change Models (GCMs) at regional and global scales and provide feedback to resource managers and environmental policy makers. Permanent research sites may be the currently operating field stations in globally and/or regionally important ecosystems.

These sites can be part of an international network that includes European partner centers and cooperating institutions and could contribute to understanding questions such as geosphere teleconnections (e.g. ENSO related variability), north-south coupling of climate variability and global change, comparisons of biodiversity and functions (e.g., carbon storage) of polluted versus unpolluted ecosystems, and comparative analysis of socio-economic drivers of agriculture/forestry practices. Several environmental centers in Chile presently have access to --or operate-- field stations (with different levels of implementation) that could integrate this network of monitoring sites, at the same time approaching questions about ecosystem functioning from an inter-disciplinary perspective.

Another interesting possibility of collaboration is in the area of integrated assessment of policy options to control local and global air pollution. Chile has been the leader in the region in the area of environmental benefits valuation and its application to public decision-making. This area has been focused primarily at the valuation of local environmental impacts, but has recently expanded to include the interactions between local and global environmental impacts. By the same reasons, impacts on changing precipitation patterns and other climate-change-based effects are interesting to be explored in Chile because of the strong N-S gradient in climate, meaning that future scenarios might include long-term changes in the pollution dispertion capacities of the most populated basins in the country, once again touching upon issues of sustainable growth therein.