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CLEAN TECHNOLOGY FOR PAPER MILLS

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May - August, 1994

Prepared for:

US - ASIA ENVIRONMENTAL PARTNERSHIP

WORLD ENVIRONMENT CENTER

DISCLAIMER

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TABLE OF CONTENTS

APPENDICES

I. EXECUTIVE SUMMARY

A three-phase Environmental Business Exchange (EBE) occurred between Esvin Advanced Technologies Limited (Esvin Tech) of India and Manufacturing and Technology Conversion international, Inc. (MTCI), located in the United States. The purpose of the EBE's was to work towards identifying appropriate technologies to eliminate the water pollution from alcohol distilleries and mini paper mills in India. A specific focus of this EBE was to solve technical problems occuring at Esvin Tech's Thermo Chemical Conversion Reactor ((TCCR) demonstration plant in Erode, Tamil Nadu, India.

In the first phase of this EBE, Mr. T.S. Venkataraman, Managing Director of Esvin Tech, visited United States for discussions with M/s ThermoChem, Inc., concerning the application of their technology for eliminating water pollution from mini paper mills based on rice straw. The discussions were aimed mainly at overcoming feed specific problems such as the formation of eutectics caused by substances such as chlorides and phosphates. Mr. Venkataraman visited the ThermoChem/MTCI, Weyerhaeuser Pulp Mill, in New Bern, North Carolina and the Mead Pulp Mill in Alabama between May 26 and June 4, 1994. He specifically addressed issues relating to the chemistry aspects of handling the rice straw liquor feed stock.

During phase two, Dr. M. Mahalingam, Senior General Manager (Thermal Group) of Esvin Tech, visited MTCI's Baltimore Laboratory, ThermoChem in Columbia, Maryland and Weyerhauser Pulp Mill in New Bern, North Carolina between July 4 and 9, 1994. In the course of this phase, Dr. Mahalingam identified the equipment configuration to suit the processing of rice straw liquor.

In the final phase of the EBE, Dr. K. Durai-Swamy visited India between July 12 and August 1, 1994. He assisted Esvin Tech in the finalization of the proposal for building an effluent treatment plan to recover chemicals and eliminate water pollution for the M/s Delta Paper Mills Limited, Bhimavaram, Andhra Pradesh. He also visited Esvin Tech's Thermo Chemical Conversion Reactor (TCCR) demonstration plant, set at the mill site of Seshasayee Papers, Erode, Tamil Nadu, and made recommendations on plant modifications needed to process the rice straw waste effluent, known as black liquor. Later he visited the commercial effluent treatment plant site at the distillery unit of Aruna Sugars and Enterprises Limited, located at Pennadam, S.A. Dist., Tamil Nadu and made recommendations on the treatment plant's start-up method and the appropriate stages involved in the plant's commissioning to achieve its rated capacity.

Funding for this project was provided though a Cooperative Agreement between the World Environment Center (WEC) and the United States-Asia Environmental Partnership (US-AEP).

II. INTRODUCTION

Manufacturing and Technology Conversion International, Inc. (MTCI) is an energy and environmental engineering technology supplier located in Columbia, Maryland, USA. Thermochem, Inc. is MTCI's marketing arm for their environmental technology. MTCI has developed an indirect gasification technology which can be employed for the elimination of water pollution from mini paper mills and alcohol distilleries. The gasification technology has been licensed exclusively to M/s Esvin Advanced Technologies Limited (Esvin Tech) for the manufacture and marketing of the Thermo Chemical Conversion Reactor (TCCR) System in India.

Esvin Tech is a sister company of Seshasayee Paper Board Ltd. (SPB) of Erode, Tamil Nadu, where Esvin Tech has built a demonstration plant under a USAID/PACT program. Esvin Tech is also building the first commercial TCCR plant for treating alcohol distillery effluent at Aruna Sugars in Pennadam, Tamil Nadu.

The exchange between Esvin Tech and MTCI will lead towards identifying technologies to eliminate the water pollution from alcohol distilleries (approximately 200 alcohol distilleries are operating in India) and mini paper mills (approximately 150 mills operating in India are on the verge of closure due to their pollution load). Esvin Tech has experienced some technical problems in the operation of the demonstration TCCR plant in Erode. Identifying and solving these technical problems is a central concern of this EBE.

III. MEETINGS HELD AND FACILITIES VISITED

A. MR. T.S. VENKATARAMAN'S VISIT TO THE U.S., MAY 26 TO JUNE 2, 1994

1. MTCI - Columbia, Maryland, May 26 to 27, 1994

Mr. Venkataraman held discussions with Dr. Momtaz N. Mansour, President, MTCI, Mr. Hany Said, General Manager & Vice President, ThermoChem, and Dr. K. Durai-Swamy, Sr. Vice President, ThermoChem, on the current status of technology and the design modifications that may be needed for handling rice straw liquor. The design features of the scaled-up Pulse Combustor were also discussed with Mr. David Scaerce who is a Design Engineer at ThermoChem.

2. Weyerhaeuser Paper Mill - New Bern, North Carolina, May 28 to 30,1994

While in New Bern, Mr. Venkataraman observed the operation of the three-tube bundle gasifier demonstration plant at Weyerhaeuser Paper Mill. The various operating parameters and their impact on the capacity and gas generating levels of the system were reviewed with Mr. Bill Steedman, Engineering Manager of ThermoChem, Inc. A specific topic they discussed was the control logic and level of instrumentation needed to maintain the targeted bed and tube temperatures

Mr. Venkataraman also studied the problems relating to operating the bed at low temperatures which must be maintained for removing low temperature-melting inorganics present in rice straw liquor. At lower temperatures, more undesirable products like tars and phenols are likely to be released with the gas, which then needs to be scrubbed properly in the downstream gas cleaning system.

3. Mead Paper Mills (Container Board Division) - Stevenson, Alabama, May 31, 1994

Mr. Venkataraman met with Mr. Wouter W. Dieperink, Manager of Engineering and toured the Chemical Recovery System and the exhaust gas cleaning system which includes multi-cyclones, a venturi scrubber, and the electro-static precipitator. This visit was very useful for understanding the various unit operations that could be adopted for efficiently scrubbing the gas, allowing it to be safely refired in Pulse Combustor.

4. MTCI - Baltimore, Maryland, June 2, 1994

Mr. Venkataraman visited MTCI's Research and Development facilities and engaged in detailed discussions with Dr. Ravi Chandran, Head of the Research and Development facilities, over the design of the Pulse Combustor for handling rice straw liquor.

B. DR. M. MAHALINGAM'S VISIT TO THE U.S., JULY 4 TO JULY 9, 1994.

1. MTCI - Baltimore & Columbia, MD., July 4 to 7, 1994

Mr. Mahalingam visited MTCI's laboratory at Baltimore and held discussions with Dr. Ravi Chandran, Head of the Research and Development facilities, on the following topics:

1. The use of diesel fuel in the pulse combustor instead of natural gas as natural gas is not available in most parts of India.

2. Special problems relating to diesel fuel combustion in the Pulse Combustor such as lack of fuel-air mixing, fuel phasing, etc.

At the end of several hours of detailed discussions, a suitable configuration for the Pulse Combustor with five aerovalves evolved and the necessary spray tips for diesel were selected. Dr. Mahalingam also hold discussions with Mr. Adel Ayoob on the modelling of gasification processes.

Dr. Mahalingam met with Dr. Momtaz N. Mansour, President, MTCI and discussed various issues relating to the mechanical design of Thermo Chemical Conversion Reactor (TCCR) system. He also visited ThermoChem, Inc. and met with Mr. William G. Steedman, Manager of Engineering to discuss fluidization aspects of the gasification process. He also met with Mr. David Scaerce, a Design Engineer for ThermoChem to discuss the structural design details of the gasifier.

2. Weyerhaeuser Pulp Mill, New Bern, North Carolina, July 8 & 9

Dr. Mahalingam visited Weyerhauser Pulp Mill to study the layout and construction features of the MTCI/ThermoChem TCCR demonstration plant. During this visit, he discussed the process control scheme and control instruments selection with Mark Toma and Sheng Wu.

C. DR. K. DURAI-SWAMY'S VISIT TO INDIA, JULY 11 TO AUGUST 3, 1994

1. Indo-U.S. Energy Summit in New Delhi, July 11-13, 1994

Dr. K. Durai-Swamy's technology assessment tour began with his participation in the Indo-US Energy Summit. The remainder of his trip was comprised of many vists with various people and to facilities, as outlined below.

2. Esvin Tech & Sanders International, Erode, Tamil Nadu, July 14, 1994

Dr. Durai-Swamy visited Esvin Tech's office in Erode, Tamil Nadu and held discussions on the various issues relating to the use of rice straw liquor in the TCCR System. He also met with Mr. Jeff Hallett of Sanders International (also a USAID Coordinator) to discuss a proposal for building a demonstration plant at the mill site of M/s Delta Papers in Bhimavaram.

3. Thermo Chemical Combustion Reactor (TCCR) Plant at Pennadam, Tamil Nadu, July 15-16 and 27-30, 1994

Dr. Durai-Swamy visited the gasifier construction site at Pennadam, S.A Dist, Tamil Nadu and made recommendations concerning the start-up method of the TCCR plant as well as the various stages involved in its commissioning.

4. TCCR Demonstration Plant at Erode, Tamil Nadu, July 18-19, 1994

Dr. Durai-Swamy visited the TCCR demonstration plant built by Esvin Tech at the mill site of Seshasayee Papers in Erode, Tamil Nadu. There he tested the new diesel injectors and found that they are also suitable for diesel firing methods applicable to rice straw liquor processing.

5. USAID/EMCAT Program, Bombay, July 21-22, 1994

On July 21 and 22, 1994, Dr. Durai-Swamy met with IDBI executives of the USAID/EMCAT Program in Bombay to discuss a proposal for the co-generation of power and steam in a sugar mill using Bagasse gasification in the TCCR system.

6. M/s Delta Paper Mills, Bhimivaram, Andhra Padesh, July 23-24, 1994

Later, Dr. Durai-Swamy visited M/s Delta Paper Mills in Bhimavaram, Andhra Padesh and held discussions regarding their final plans for an effluent treatment plant that will recover chemicals and eliminate water pollution. Two alternative schemes were proposed. The first scheme utilizes a TCCR plant for the recovery of chemicals. The second, more attractive scheme combines power generation with chemical recovery. He later held discussions with Esvin Tech's engineers to work out the cost/benefit details of the two schemes proposed at M/s Delta Paper Mills.

7. Andhra Sugars, Tanuku, Andhra Padesh, July 25-26, 1994

Dr. Durai-Swamy held discussions with executives of Andhra Sugars on the topic of co-generation using the Bagasse technique on spent distillery wash in the TCCR system. India can substantially benefit by utilizing this technology for power generation because the approximately 400 sugar mills in India could meet local power demand if they were to adopt this method.

8. Regional Research Laboratory, Trivandrum, Kerala, July 30 to August 2, 1994

At the Regional Research Laboratory (RRL) Dr. Durai-Swamy discussed the possibility of using the TCCR technology for ilmenite ore reduction with Dr. Surender and Dr. Damodaran, Director of RRL. They also explored the idea of using the ilmenite ore as bed material in the TCCR system for processing the black liquor effluent released from rice straw based mini paper mills.

Dr. Durai-Swamy also held discussions with Dr. G.D. Surender of RRL and Dr. Mahalingam and Mr. T.S. Venkataraman of Esvin Tech regarding the use of a pulse indirect heater for mineral processing applications, ilmenite in particular, and black liquor co-processing to simultaneously recover DARS alkali and synthetic rutile, TiO_2,.

9. American Consulate General, Madras, August 3, 1994

In Madras, Dr. Durai-Swamy met with the American Consulate General to discuss the possibility of a project for TiO_2 recovery under US-AEP's Environmental and Energy Technology Fund. While in Madras, he also met with two US-AEP officials, Mr. R. Swaminathan, Commercial Advisor, and Ms. Starlet Jogabeth, Environment Market Research Coordinator.

IV. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Based on site visits and discussions, the technical problems encountered at the Erode, Tamil Nadu TCCR demonstration plants were addressed.

2. It was decided that rice straw black liquor recovery could be achieved using the MTCI technology. The economics of the project will be enhanced if a co-generation package involving an engine/generator set that would use the product gas from the black liquor gasifier is also included. The customer, Delta Paper Mills, has requested that Esvin Tech prepare a proposal that comprises the chemical recovery pollution controls and co-generation elements by mid-September.

3. Based on the visit and discussions of Dr. Durai-Swamy to Regional Research Laboratories (RRL) and a subsequent visit and discussions by Dr. G.D. Surender of RRL to Esvin Tech, it was decided to pursue the application of the MTCI indirect heated fluid bed reactor in the recovery of titanium dioxide from ilmenite ore. This will lead to a reduction of both energy use and environmental pollution. For the feasibility evaluation of the proposed concept, approximately $20,000 of external funding is needed.

RECOMMENDATIONS

1. Esvin Tech must submit a proposal to Delta Paper Mills in September 1994 concerning appropriate chemical recovery schemes.

2. Help Delta Paper Mills apply for ICICI financing in October 1994. Esvin Tech, RRL and MTCI should work out a detailed Memorandum of Understanding (MOU) by September 1994, giving details of each party's roles and goals.

3. MTCI, RRL and Esvin Tech shall also identify sources of funds and send applications to those identified sources.

4. Esvin Tech should pursue the marketing of co-generation projects at alcohol distilleries and sugar mills in India.

APPENDIX A

ITINERARY

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Mr. T.S. Venkataraman's Visit to the U.S.

May 26-27, 1994	MTCI in Columbia, Maryland.
May 28-29, 1994	Weyerhauser Paper Mills in New Bern, North Carolina.
May 31, 1994	Mead Paper Mills in Stevenson, Alabama.
June 2, 1994	MTCI in Baltimore, Maryland.

Dr. M. Mahalingam's Visit to the U.S.

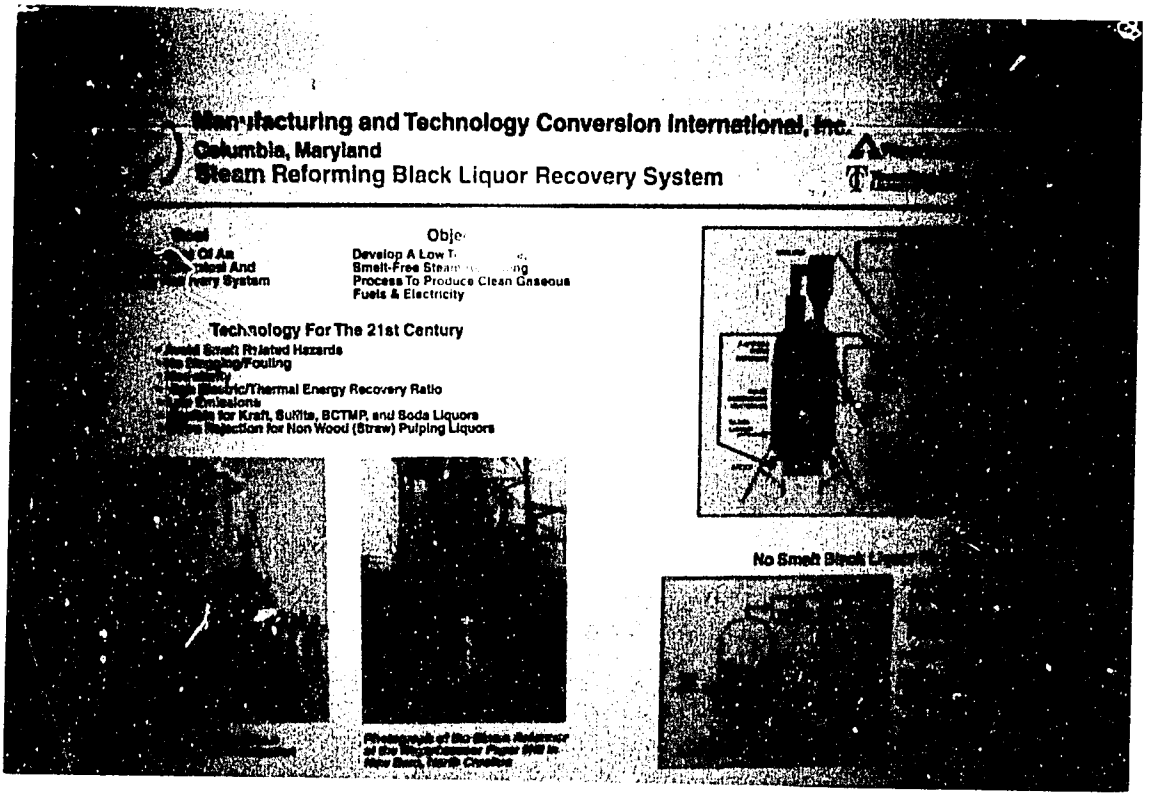
July 4-7, 1994	MTCI in Baltimore and Coumbia, Maryland.
July 8-9, 1994	Weyerhauser Paper Mills in New Bern, North Carolina.

Dr. K. Durai-Swamy's Visit to India

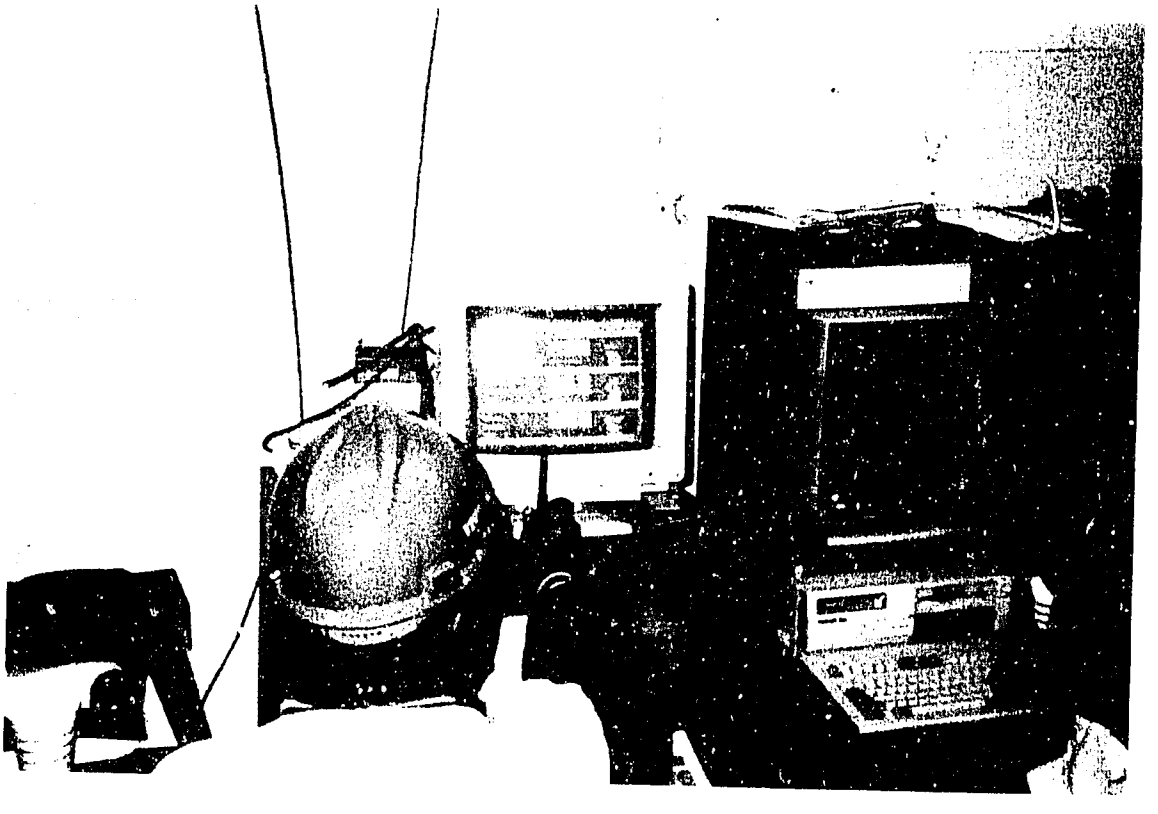
July 11-13, 1994	Indo-U.S. Energy Summit in New Delhi.
July 14, 1994	Esvin Tech in Erode, Tamil Nadu.
July 15-16, 1994	TCCR plant in Pennadam, Tamil Nadu.
July 18-19, 1994	TCCR demonstration plant in Erode, Tamil Nadu.
July 21-22, 1994	USAID/EMCAT officials in Bombay.
July 23-24, 1994	M/s Delta Paper Mills in Bhimavaram, Andhra Padesh.
July 25-26, 1994	Andhra Sugars in Tanuku, Andhra Padesh.
July 27-30, 1994	TCCR plant in Pennadam, Tamil Nadu.
July 30 - Aug. 2, 1994	Regional Research Laboratories in Trivandrum, Kerala.
August 3, 1994	American Consulate General in Madras.

APPENDIX B

PHOTOGRAPHS



Discussion at Thermochem/MTCI
May 27, 1994



Discussion at New Bern Facility

Participating in Trials at the New Bern Demo Plant

Visit to Mead Paper Mill
Stevenson, Alabama

APPENDIX C

CURRICULUM VITAE

DR. K. DURAI-SWAMY

SENIOR VICE PRESDIENT
PRODUCT MARKETING

EDUCATION

Ph.D. - Fuels Engineering, University of Utah (1973)
M.E.A. - Industrial Engineering, University of Utah (1971)
M.S. - Chemical Engineering, Bucknell University (1970)
B.E. - Chemical Engineering, Annamalai University, India (1967)

EXPERIENCE

Thermochem, Inc.
SENIOR VICE PRESIDENT
As Senior Vice President for Product Marketing, Dr. Durai-Swamy is responsible for the commercialization and market entry of new technologies as well as emerging sales of all products.

Manufacturing & Technology Conversion International, Inc.
SENIOR VICE PRESIDENT
As Vice Presdient of Technology at MTCI, Dr. Durai-Swamy managed the West Coast Operations. His responsibilities at MTCI encompass the direction of research development and field testing of the MTCI advanced steam reformer (gasifier) and enhancing the utilization of pulse combustors for industrial applications. He is a co-inventor of the MTCI Steam Reforming Process.

Foster Wheeler Development Corporation
MANAGER
As Manager of the Chemical Process Department, he supervised the operation of ten pilot plants and their design, modification, construction, and maintenance. He was responsible for conceiving, planning, and supervising research programs relating to chemical petroleum refining processes.

Dr. Durai-Swamy is a Registered Professional Engineer in the State of California. He has several publications and 15 U.S.patents.

Name	**T.S. Venkataraman**
Residential Address	
Name and Address of the Organization	**Esvin Advanced Technologies, Ltd.** "Esvin House" Perungudi Madras 600 096 - India Tel: 4926056; Fax: 4925525 Telex: 41-21058 ESVI IN and 41-21072 SPB IN
Present Position	**Managing Director**
Date of Birth	
Nationality	Indian
Academic Qualifications	M. Tech (Chemical Engineering) Madras University, India M.S. in Pulp and Paper Technical University of Norway Trondheim, Norway

Brief Account of the Provessional Career

Presently acting as the Chief Technologist, leading a team of Scientists of the Company in addressing the following areas:

1. Development of the Thermo Chemical Conversion Reactor System in collaboration with M/s Manuracturing and Technology Conversion International (MTCI), USA, for chemical recovery by indirect gasification of black liquor suitable for small and medium agro-based paper mills in India. Demo plant is commissioned at the mill site of Seshasayee Paper, Erode.

2. Development of Microbial Systems for Biodegradation of lignin for cost effective pulping, bleaching and decolourization of paper mill effluents in association with National Institute of Oceanography (NIO), Goa.

3. Development of a process for Demineralisation of sugarcan juice using electrodialyses in technical association with Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar, Gujarat.

Have visited Cuba as a Special Invitee or UNDP and Cuban Government for participating in an International Seminar on Newsprint from Bagasse held at La Habana, Cuba in October, 1990.

Worked as Consulting Technologist in SPB Projects and Consultancy Limited (SPB-PC), Madras, India, between 1986 and 1988 providing assistance in technology related problems in their feasibility studies for various projects such as newsprint, medium density fibre board, tissue etc., based on bagasse. Also visited Germany, France, Sweden, The United Kingdom, Japan and South Korea, for evaluating the state-of-the-art of technology for manufacture of bank note paper on behalf of Government of India.

Worked as a Visiting Scientist at Beloit Research Centre, Massachussets, USA, for two years in the joint development of "Beloit-SPB" Process for Tamil Nadu Newsprint and Papers Limited, Pugalur, Trichy, India. Have visited various bagasse-based paper mills in countries like Peru, Mexico, Argentina, Cuba, Indonesia, Thailand, Philippines, etc.

Worked as Assistant Manager (Marketing) at Hindustan Dorr-Oliver Limited, Bombay, india, between 1980 and 1982.

Worked in Seshasayee Paper and Boards Limited (SPB), Erode, India, since 1969 holding various positions as Manager for Process Engineering, Quality Control, Project Engineer, etc., until 1980.

Memebership

Member of TAPPI - was also a Committee Member for the Non-Wood Plant Fibres Division during the years 1983 to 1986.

Member of Indian Pulp and Paper Technical Association (IPPTA).

Member of Indo-American Chamber of Commerce (IACC).

Member of Southern Indian Chamber of Commerce and Industry (SICCI).

Member of Indian Membrane Society.

Technical Papers Published:

1. "The Role of Impregnation in the High-yield Pulping of Bagasse for Manufacture of Newsprint, Fine Paper and Liner Board," TAPPI Pulping Conference: San Francisco, 1984.

2. "Investigation of the Relationship Between the Quality of Bagasse Based Pulps and Newsprint," TAPPI Pulping Conference: Florida, 1985.

Name	**M. Mahalingam**
Date of Birth	
Father's Name	Masilamani
Marital Status	Married
Residential Address	
Nationality	Indian
Passport No.	
Name and Address of the Organization	**Esvin Advanced Technologies, Ltd.** "Esvin House" Perungudi Madras - 600 096 - India Tel: 4926056; Fax: 4925525 Telex: 41-21058 ESVI IN and 41-21072 SPB IN

Academic Qualifications:

B.E. (Mechanical) - Distinction
1976, Annamalai University
Best Award Winner

M.E. (Boilers) - Distinction
1981, Regional Engineering College, Tiruchirapalli

BHEL Sponsored Programme with faculty support from BHEL's design and production departments.

Ph.D. (Heat Transfer)
1991 - Indian Institute of Technology, Madras.

Heat Transfer Studies in circulating fluidized beds.

Professional Qualifications:

1976-8	Junior Plant Manager/Boiler Operation **M/s Neyveli Lignite Corporation Ltd**, Neyveli
1978-85	Engineer Trainee Product Engineer Senior Product Engineer Boiler Designs Boiler R&D FBC Development **M/s BHEL**, Tiruchirapalli
1986-88	Technical Manager
Aug. 1991 onwards	General Manager **Uttam Industrial Engg. P. Ltd.**, Ghaziabab (Turnkey Sugar Plant Supplier)

Carrer Achievements:

A. While serving at **M/s N.L.C. Ltd.**

1. Solved the fuel pipe line erosion problem by carrying out pitot traverse studies to limit the P.f. air stream velocity below the erosion threshold velocity.

2. Reduced the chemicals consumption for water treatment by modifying the reaction regimes.

3. Solved the ash disposal problem through redesigning the Hydro Val jets and system.

B. While serving at **BHEL**, Trichy.

1. Developed a versatile computer software application for the generation of combustion data for various bio-fuels.

2. Conceived and designed a zero leak flue gas damper for 500 MW steam generator applications (an import subscription project).

3. Was instrumental in implementing furnace oil conservation at the seamless tubes project under the supervision of Dr. R. Vasudevan.

4. Lead Engineer in the development of FBC combustor for rice husk fuel supplied to M/s Pamani Fertilizers.

5. In association with Dr. R. Vasudevan, proposed co-generation of power from sugar factories project - for DST funding in 1982. Complete technical proposal was worked out to prove the feasibility.

6. Served as Honorary Director/BHEL AMIE Trg. Inst.

7. Served as Visiting Faculty to REC, Trichy, IIT, Madras and TTTI, Taramani.

8. Carried out energy audits in sugar, ceramic, and furfural plants.

C. While serivng at **UTTAM.**

1. Converted UTTAM's status from equipment supplier to full plant supplier within a period of five years through business strategy planning, technical capability upgrading, and company image building.

2. Brought in technical collaborations for business diversification.

Paper Publications:

1. 1981 "Bagasse Fired Boiler Design," paper presented in National Seminar, NPC, New Delhi.

2. 1982 "Waste Heat Recovery," paper presented in National Seminar, NPC, Calcutta.

3. 1983 "Steam Generation," lecture paper - Boiler Operator's course, BHEL, Trg. Center.

4. 1984 "FBC - For BIO-MASS," paper presented at Bio Energy Society Annual Convention.

5. 1985 "FBC Boilers for Sugar Mills," *Co. Op. Sugar Journal*, April 1985, Vol. 16, No. 8.

6. 1986 "FBC & Energy Conservation," paper presented at NPC, Gorakhpur.

7. 1988 "Heat Transfer in FBC," seminar paper at IIT, Madras.

8. 1990 "Heat Transfer Model for the Membrane Wall of CFBC Boiler," paper presented at the International Conference, Nagoya.

9. 1991 "Heat Wall Transfer in CFBC," *AICh.E Jl.*, Vol. 37, No. 8.

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WEC/US-AEP

Environmental Business Exchange (EBE) Trip Reports

Febuary 22, 1995

Trip Reports as per Cooperative Agreement (CA) AEP-0015-A-00-2055-00 in Support of the U.S.-Asia Environmental Partnership

EBE ID#	EBE DATES	TITLE OF TRIP REPORT
INDI-1I	11/7-23/93	Oil Absorbent Demonstration
INDI-1K	12/6-29/93	Review of Incinerator Operations, Indian Thermal and Cyno Clean
INDI-2	4/23 - 5/6/94	Review of Pollution Prevention Control Technology in the Textile Industry
INDI-5	4/30 - 5/10/94	Clean Coal Technology Evaluation
INDI-1P (1&2)	5/94-8/94	Clean Technology for Paper Mills - Esvin - Parts 1&2
INDI-1R	6/18-30/94	Evaluation of Biological Formulations for Industrial Wastestreams Treatment (Premier Ziba)
INDI-1Q	6/18-7/1/94	Indian Boilers Manufacturers' Association Trade Mission
PHIL-8	9/27-10/6/94	Technical Assistance on H2S Gas Abatement Systems (PNOC)
HONG-1	10/23-11/9/94	Coleman Energy and Environmental Systems Technology Transfer
KORE-1	12/9-22/93	Fuel Gas Desulfurization Technology Assessment (KEPCO)
INDI-1L	1/17-2/23/94	Corporate Environmental Mission (IT Corporation Exchange)
INDI-4	3/11-30/94	Evaluation of CS_2 Recovery in Rayon Mills