"Promotion of Energy Research and Energy Activities at AUB"

Irani-Fund

Cost Center: DCR-11304024300

Final Report

THE AMERICAN UNIVERSITY OF BEIRUT
THE FACULTY OF ENGINEERING AND ARCHITECTURE
Energy Research Group

Reporting Period
January 1, 2001– October 15, 2003

Recipient
Energy Research Group

Submitted to:

President Waterbury

October 20, 2003

Acknowledgement

The Energy Research Group would like to acknowledge the donation of Dr. Ray Irani, member of the Board of Trustees at AUB and CEO of Occidental Petroleum. Dr. Irani's donation has allowed us to move forward in our effort to undertake interdisciplinary energy research that has an impact in Lebanon and abroad. We are grateful to Dr. Irani.

Introduction and Background

The Energy Research Group was founded by 10 members of FEA faculty in April 2000 in an effort to integrate resources for interdisciplinary energy research and create center for excellence in energy research and energy studies with emphasis on innovative technology transfer and integration with social and economic development in the region. ERG members have been active in researching problems of energy conservation, conversion, utilization, and distribution, and have at their disposal the research facilities offered by the Energy Laboratory, the Electrical Machines and Drives Lab, the Environmental Research Lab, and the Geographic Information Systems Laboratory.

In response to AUB President Waterbury's efforts to solicit seed funding for the ERG, Dr. Ray Irani, member of the Board of Trustees at AUB and CEO of Occidental Petroleum generously donated $100,000 to AUB for the ERG on December 9, 2000. The funds have been used to initiate four research programs by the group members, and to support a local workshop titled "Meeting the Energy Challenge" on May 30, 2001 for policymakers and non-governmental organizations This seed funding has already resulted in several concrete achievements, including the establishment of a thermoelectric power generation lab, the completion of several Master's theses, and publications by group members in international journals. This has given the ERG some measure of credibility and put it in a stronger position to attract additional research funding and high-quality graduate students, and in the long run, to influence energy policy in Lebanon.

In addition to initiating new research programs at AUB, ERG members have in the past 3 years worked with ESCWA in Beirut on several projects with regional and international dimensions on energy efficiency, air pollution, energy education, and energy management,. For example, one ERG member, with ESCWA support, developed a website for the Arab Development Network for the purpose of dissemination of sustainable development knowledge to local communities throughout the Arab world. ERG also has been awarded a "train the trainer" grant from the US Department Of State on "Enhancing Environmental Sustainability through Energy Efficiency & Renewable Energy Technologies" (2002-04) for the amount of $176,000. ERG is also creating a regional collaborative energy program with three other universities in the Middle East: Jordan University of Science and Technology, Birzeit University, and Palestinian Polytechnic University, with partners in the US, namely the Energy Education Institute, Florida Solar Energy Center, and the Partnership for Environmental Technology Education. Other ERG projects on

sustainable development, climate change, solid waste, and the environment have also been supported by the World Bank, UNDP, and the Ministry of Environment.

Finally, ERG has been nominated by the UN to become a member of the Global Network on Energy for Sustainable Development. GNESD is a UNEP facilitated knowledge exchange network among institutions and companies concerned with energy, environment and development issues. The Network was launched at the 2002 World Summit on Sustainable Development and currently consists of eight internationally renowned developing country Centers of Excellence in the fields of energy and environment. Current activities embrace a Working Group on "Energy Access", sharing knowledge on energy policies in developing countries with the aim of increasing the poor's access to modern energy services. ERG was the only group nominated to the membership by UNDP from the Arab World.

In summary, the ERG has been quite active on both the technical and policy fronts. In the following pages, these efforts as well as the current status and future directions of the four research programs initiated with seed funding from Dr. Irani are presented.

ERG Activities that are funded by the Irani Fun

Meeting the Energy Challenge Workshop.

Organization of a special one-day workshop *on "Meeting the Energy Challenge of Lebanon"* on Wed. May 30, 2001 (Appendix A). The workshop was attended by around 120 professionals and policy makers from Lebanon and has officially launched ERG to the community by highlighting its mission, areas of specialty, staffing, facilities, and activities. The workshop was a platform for decision-makers, experts, as well as NGOs on various energy issues in Lebanon with the aim of improving the overall efficiency of the energy sector. The workshop has also resulted in cooperation with ESCWA and UNDP, where one ERG member has been invited to attend a one-week intensive training workshop on wind energy in Egypt during the month of September, 2001. The workshop was partially sponsored by ESCWA, but AUB has covered per diem expenses.

Research programs initiated by the Irani Fun

[Actual cost: $83,000]. The majority of the IraniGrant has been dedicated to providing seed funding for four research programs selected by the ERG and approved by the Dean of the FEA. The work on the projects started in October 2001 and the duration of the first phase varied from 12 to 18 months. The final reports of the first phase are submitted with this report as supplementary documents. [Nesreen, the following sentence should go elsewhereAt the request of the Dean, the remaining funds of $12,000 were allocated to support graduate students working in the area of energy]

The seed funding was used to support graduate students hired as research assistants, faculty summer salaries, and to purchase research equipment and software needed for these programs. Three major software have been already acquired which are:

i) GAMS Base Module with the CPLEX solver which is a high performance Linear and Integer Programming Solver for use in the development of the energy model of Lebanon project,
ii) Finite Element Simulation of Electromagnetic Fields and Devices, and
iii) Breeze Haz Professional software which provides the necessary tools for modeling most accidental chemical release scenarios that result in either a dispersing toxic plume, fire, or explosion.

Further details by program are given below.

Program 1
"Development of low-cost distributed thermo-electric power generation technologies for rural areas"

Rida Nuwayhid, Alan Shihadeh, Nesreen Ghaddar, Fadl Moukalled

Phase 1 duration: 18 months, October 1, 2001-March 31, 2003

Abstract
This program aims to develop thermo-electric power technologies that can be used in low-income areas for the purpose of small scale, distributed off-grid electric power generation. The first project taken up by members of the ERG in this direction was titled "Development of a domestic woodstove thermoelectric generator with natural convection cooling," and its immediate goals are a) to develop a low-cost/high-performance thermoelectric module, and b) to investigate the power producing potential of this module when coupled to a conventional domestic woodstove, using natural air convection as the heat rejection method. This thermo-electric generator is envisioned to be used in rural areas during the winter, especially where grid electricity is expensive, erratic, or unavailable.
To date, a high-performance, low cost thermoelectric generator [TEG] unit was designed, built, and tested. It was fitted to a common rural wood stove, whose firing rate and heat transfer characteristics were experimentally determined . Using the stove side surface as the heat source, a maximum of 4.2 W per single TEG module was been obtained. It was also found that for a given heat sink and heat source, increasing the number of TE modules *decreased* power output although higher voltages could be realized at some loss in available electric current. Based on the price of the materials purchased in this work, the cost for a single module TEG a system was 0.24 $/W.

While the electric power was considerably lower than the 25 W target, it has been demonstrated that a form of combined heat and electric power system such as a could be achieved at a low cost with minimal complexity and potentially usable output. Continuing work on this project is focusing on improving the heat rejection rate to increase the TEG output. Alternatives to natural convection cooling scheme for heat rejection are being developed. These include a thermosyphonically-driven cooling water circuit through the heat sink (i.e., potentially coupled to a domestic water heating system), phase change materials, and heat pipes.

Project Outcomes to Date

1- Establishment of a thermoelectric testing laboratory in the FEA

- Setup of data acquisition system for temperature, power, and voltage signals
- Design and manufacture of a uniform surface temperature TEG testing device capable of independent variation of hot and cold side temperatures.
- Acquisition, installation, and modification of two domestic wood stoves for TEG

1- Project Final Report.
2- Publications
   - Nuwayhid R.Y., Shihadeh A, Ghaddar N, **"**Development and Testing of a Domestic Woodstove Thermoelectric Generator with Natural Convection Cooling", Energy Conversion & Management, submitted, October 2003
   - Ghaddar N. K. Ghali, and M. Salam. "Steady Thermal Comfort by Radiant Heat Transfer: Impact Stove and Stack Position" Submitted September 2003. First International Conference on Thermal Engineering. Beirut, May 31-June 4, 2004.

3- Master's thesis in progress
   Bassel Munzer: "Development and Testing of a Domestic Woodstove Thermoelectric Generator with Heat Pipe Cooling"
   Mohamad Salam: "Optimization of stove and stack design and operation for energy efficiency and thermal comfort".

4- Final year projects and undergraduate education
   "Bench-scale thermoelectric generator performance testing unit
   Students names: N. Diab, Z. Wehbe, W. Bleik and O. Zahnan.
   Supervisors: Nuwayhid and Shihadeh.
   "TEG Heat Sink Design and Simulation using FLUENT" Course project. MECH 420. Supervisor: Prof. Moukalled.

5- Other proposals submitted for funding
   The stove proposal was expanded and was submitted to both US AID and Merci Crops

Project 2

Title: "Developing a Comprehensive Environmental Compliance and Phasing Program for the Paper Industry in Lebanon."

By: Toufik Mezher (PI) and Moutassem El-Fadel
Duration: October 1, 2001 till September 30, 2002.
Amount: $20,000

Project Abstracts:

Project Outcomes

Two Final Projects Reports are submitted:

1- M. Fadel, T. Mezher, and N. Salem. " Sequential Batch Reactors for the Treatment of Paper Mill Wastewater". January, 2003. AUB-ERG.
2- T. Mezher, M. Fadel, and W. Farkouh. "Economic and environmental Impacts of Technology in the Pulp and Paper Industry in Lebanon." January, 2003. AUB-ERG.

Two projects were completed by the students Salem, and Farkouh towards their Master of Engineering degree in Engineering Management.

Project 3

Title: "An Environmentally-Aware Energy Model of Lebanon"
By: Sami Karaki, Farqad Al Khal & Mutasem El Fadel

Duration: 18 months, October 1, 2001-March 31, 2003

Abstract. The main energy sectors of Lebanon are being identified, studied and understood. Primary energy forms taken at the supply are transformed into useful forms and delivered to various sectors, which were identified as the residential, commercial, governmental, industrial, and transportation sectors. The interconnection of these different sectors among themselves and the quantification of the processes within each are now being conducted based on data collected from field investigations, on statistical reports and studies of government, and international institutions. A prototype model of the transportation sector completed. The approach here is to develop the models of individual sectors and then link the various sub-models together. The entry and exit points of the transportation sector have been identified and the internal exchanges among its various processes are being quantified along with the process efficiency, upper limit, and cost. The parameters of the developed industrial sector model are being tuned and validated using past data. The work now being developed will provide us with many lessons and fundamental experience in modeling realistic systems that will be transported to other sectors and to the model as a whole. The model for the electric energy production sector is being developed and of the Lebanese industrial sector. The work will be completed with eventual integration of the three models for producing a valuable tool for decision making of energy policies in Lebanon.

Project Outcomes

1- Publications (Copies available upon request)

- S. Karaki, P. Khoury, N. Ghaddar, F. El-Khal, and M. El-Fadel. " A normative Model of the Lebanese Transportation Sector". submitted to the Applied Energy journal, August 2003.

- S. Karaki, R. Bou Ghanem, and F. El-Khal. "The modeling of the electric Energy Production sector in Lebanon" Submitted to Energy Conversion and Management.

2- Master Students

- Mr. Rony Bou Ghanem. Thesis title: “The modeling of the electric Energy Production sector in Lebanon”. Supervisor: Prof. Sami karaki.

- Mr. Bassem Bohsali Thesis title: “ Modelling the Industrial Energy Sector in Lebanon.” The thesis will be completed by Ocober 2003 and will later be published.

- Mr. Pierre Khoury Thesis title: “An integrated energy model of Lebanon.”

3- Other proposals submitted for funding

- A proposal on establishing a training center at AUB for the Optimum Power System Operation. It was developed in cooperation with Prof. Bo Eliasson of the University of Malmo, Sweden. It was submitted the NSF under Solicitation No. NSF-02188. Unfortunately it was rejected. Profs. Karaki is attending to the comments raised by the reviewers and plan to seek funds for it from other sources. \

- The development of a new proposal to tune the energy model of Lebanon involving regional funding agency and the government and elevate the developed model into a tool that can be used for decision making in energy policy in Lebanon.

Project 4

Title: A CAA/CAD Analysis of Electrmagentic Suspension System

By: Farid B. Chaaban and Riyad Chedid

Duration: October 1, 2001 till September 30, 2002.

The project is aimed at conducting a finite element analysis of an existing electromagnetic suspension system so as to optimize the design parameters and to predict the performance under various operating conditions. The design optimization would lead to reducing the amount of electric current/energy needed to perform the system. Furthermore, current reduction results in system efficiency improvement.

Project Outcomes

Tasks accomplished during the period from October 1, 2001 through September 2003 can be briefed as follows:

1. The electromagnetic suspension system, initially developed at FEA by a group of students as a final year project, has been upgraded through the design of a more complex sensors/control system (Spring 01-02). The cost of the required electronic components was covered from the project allocated budget.
2. The finite element (FE) software (MagNet 6.9) has been purchased and installed. It is currently used to accurately model the electromagnetic suspension system in two dimensions (2D).
3. The FE package has been used as a teaching and research tool in undergraduate as well as graduate courses currently offered at ECE/FEA.

4. A project on FE modeling and analysis has been offered during Fall 02-03 term as a term paper for the “Electric Drives (EE013E)” course offered for 4th year students.
5. A final year project on “Design of MHD generator using FE method” has been conducted by a group of 3 students in Fall and Spring 02-03 terms.
6. A graduate Assistant is further investigating the same topic.
7. Outcomes of these activities on FE modeling and analysis will be sent for eventual publication in international journals.

Financial Statement

The total fund amount donated to ERG was $100,000. Table 1 shows the expenditure on each activity supported by the grant. The detailed statement issued by the comptroller is given Appendix B.

Table 1. Grant Expenditure[Cost Center: DCR-11304024300]

Activity	Description	Expenditure ($)	Total ($)
ERG Workshop May 30, 2001	Supplies, Printing Material – Newsletter – Conference Room	4,700	**4,700**
Project 1 Design and Optimization of Coupled Domestic Stove/Thermoelectric Generator Devices Using Olive Residues as Fuel.	Summer salary of 1 man-month (Aug. 2002) Prof. R. Nuwayhid Prof. A. Shihadeh Prof. F. Moukalled	 3,282 3,282 3,282	**$30,000**
	Research Assistant and Casual Labor 1. Jinan Abi-Rabiaa 2. Maim Adwan 3. Firas Matraji 4. Wissam Sarkis	10,000	
	Materials/Supplies - Stoves, TEG Modules, Fuels, Chemical analysis, Supplies, Burners/ tubing for exhaust gases. - ASPEN Software for Energy and Exergy Analysis of Thermal Systems	 8,000 2,000	
Project 2 Developing a Comprehensive Environmental Compliance and Phasing Program for the Paper Industry in Lebanon	Summer salary of 1 man-month (Aug. 2002) - Prof. Mutasem El-Fadel - Prof. Toufic Mezher	 3,481 3,481	**$20,000**
	Emission / dispersion software	7,000	
	Materials/supplies and logistics Chemical analysis ($2,000) Transportation/travel ($1,638) Publication cost ($500) Miscellaneous expenses ($1,500)	5,362	
Project 3 An Environmentally-Aware Energy Model of Lebanon	Casual Labor, RA's, GRAs Roni Bou Ghanem Pierre Khoury	10,000	**13,000**
	Computer Software/ Books/ Reports	3,000	
Project 4 A CAA/CAD Analysis of Electrmagentic Suspension System	Summer salary of 1 man-month (Aug. 2002) Riad Chedid Farid Chaaban	 3,481 3,481	**$20,000**
	Finite Element software	7,500	
	Research Assistants: Ali Daher Maha Choubassi	2,500	
	Components	1,500	
	Publication and conference charges	500	
	Miscellaneous	638	
		Total	**$87,700**
		Remaining Amount	**$12,300**

Ongoing Work and Initiatives

ERG has actively pursued a grant from the Department of State on Enhancing Environmental Sustainability through Energy Efficiency and Renewable Energy Technology for the amount of $176,000. The grant has sponsored a 5-day workshop on energy efficiency in Larnaca, Cyprus during the period April 20-25, 2003. The workshop objective was to provide the practical knowledge the partner universities from the region need to institute special training programs in energy efficiency/energy auditing, to introduce these subjects into coursework within their engineering departments, and to offer advisory services to government ministries and commercial establishments. It was delivered by two trainers from the US from the North West Energy Education Institute NEEI and attended by 16 participants coming from four partner universities in the Middle East. The partner universities are: American University of Beirut (AUB), Jordan University of Science and Technology (JUST), Birzeit University, and Palestinian Polytechnic University (PPU). From ERG and FEA the following faculty attended the workshop: Nesreen Ghaddar, Fadl Moukalled, Toufic Mezher, Marwan Darwish, Rida Nuwayhid, and Abdel-Halim Jabr.

Based on the above training, ERG has also introduced a new course on Energy Efficient Buildings jointly between Department of Mechanical Engineering and Department of Architecture. The course is offered to FEA students this current semester (Fall 2003-04).

Two of ERG members, Ghaddar and karaki, participated in a 3-week training program on renewable energy technology at Florida Solar Energy Center in the US during the summer of 2003, along with participants from Jordan and Palestine. The training program resulted in preparing a proposal Titled: “A Testing and Certification Facility for Solar Collectors and Photovoltaic Modules in Lebanon: An Initiative for Solar Technology Market Penetration and Barrier Removal”. The proposal is written by Ghaddar, Karaki and Shihadeh and funding will be pursued through UNDP and similar agencies that support sustainable energy initiatives.

ERG is planning a regional collaboration workshop on Energy Efficiency and Renewable Energy Technology that will be held in During Spring of 2004, that will lay the foundation for how the partner Middle East universities will collaborate to facilitate the adoption of energy efficiency and renewable energy technologies and practices in their region. The workshop is sponsored by DOS and will result with an Action Plan for Regional Sustainable Energy Development. Energy Experts from US, UNDP, UN, World bank, and Middle Eastern Universities AUB, JUST, PPE, and Birzeit will attend the workshop.

Several ERG members have written proposal that were submitted for funding to USAID, NSF, and similar that got rejected. Members will attend to the reviews and continue soliciting competitive funding for their research proposals. Securing external funding was not an easy endeavor for ERG members.

There are particular projects done by the Energy Research Group members as consultants that has regional or international dimensions and towards energy policy. Table 2 lists these recent projects/consultancies.

List 2: Recent Projects and Consultancies by ERG members

No.	Project Description	ERG member	Date
1	UN/ESCWA on building Knowledge Management strategies for different sectors in Lebanon and other ESCWA countries	T. Mezher	2003
2	Design and Development a Web Site for Arab Development Network for the purpose of dissemination of Sustainable Development knowledge to Local Communities throughout the Arab World. It is a multi-lingual system (English and Arabic). ESCWA	T. Mezher	2003
3	International Research Collaboration with MIT on developing a knowledge-based system called Global System for Sustainable Development (GSSD)	T. Mezher	2000 - present
4	ESCWA Members Countries on Energy and air pollution	R. Chedid F. Chaaban	July-September 2002
5	Energy Efficiency in the Industrial Sector in the Arab Countries (ESCWA)	R. Chedid F. Chaaban	July-September 2002
6	Climate Change Enabling Activity, Phase II. Agency: Ministry of Environment/UNDP. Activity: Technology Needs Assessment and Technology Transfer for GHG Reduction in the region with networking	Profs. Chaaban, Chedid, and Fadel	July-September 2002
7	Business Plan for Kadisha Electricity Company. Agency: Kadisha Electricity Company. Activity	F. Chaaban - Consultant	January 2003
8	Developer's Guide for Efficient Use of Energy in the Tourism Sector. Agency: ESCWA.	F. Chaaban - Consultant	July-August 2003.

Projects Evaluation

Based on the work done it provide the basis for attracting

Although the Irani funding has led to increased research/consultancy output of the ERG members, the funding was given to ERG at a time of transition in AUB culture toward a more dynamic and critical approach to encouraging basic and applied research and providing physical resources and environment for conducting research. ERG had members who are interested in doing work in new areas and

Appendices

The American University of Beirut
The Energy Research Group

GNESD
GLOBAL NETWORK ON ENERGY FOR SUSTAINABLE DEVELOPMENT
Facilitated by UNEP

Dear Professor Nesreen Ghaddar,

17 September 2003

It is with great pleasure that I can inform you that the Interim Steering Committee of the Global Network on Energy for Sustainable Development (GNESD) has identified ERG as a potential member of its expanding Network.

GNESD is a UNEP facilitated knowledge exchange network among institutions and companies concerned with energy, environment and development issues. The overarching objective of GNESD is to promote sustainable development and poverty alleviation by expanding the knowledge base about the environmentally sound provision of energy services.

The Network was launched at the 2002 World Summit on Sustainable Development and currently consists of eight internationally renowned developing country Centres of Excellence within energy and environment. Current activities embrace a Working Group on "Energy Access", sharing knowledge on energy policies in developing countries with the aim of increasing the Poor's access to modern energy services. Please see the attached Newsletter for additional information.

The Interim Steering Committee has decided to look into the possibility for expanding the Network membership with an additional number of developing country Centres of Excellence. In order to determine ERG's interest in and potential for joining GNESD as a Network Member I have attached a short questionnaire which I kindly ask you to fill in if you find the possibility of membership interesting. Selection will be carried out based on a set of criteria including substantive contribution, regional balance etc. If your institution is selected to join the Network you will be invited to participate in the annual GNESD Partner Assembly in Nairobi, Kenya, 22 November 2003.

The Partner Assembly will decide on the coming two-year's strategic plan, work programme and budget. Other topics will be to provide general guidance regarding the priorities and direction of the Network's activities and receive reports from the Working Groups on activities conducted under the aegis of the Network.

Being a Member of GNESD will give ERG the possibility for influencing the work carried out in the GNESD Working Groups. In addition, membership gives easy access to Network findings through the restricted area of the GNESD website. This being reports, analytical tools or other material. Members can participate in any of GNESD's ad hoc Working Groups where they can be contracted by the GNESD Secretariat to make a substantive contribution to the work.

Please return the questionnaire as either scanned email, by fax or by ordinary post to the address shown below. Filled in questionnaires should be returned by 5 October 2003 to be part of the final selection by the Interim Steering Committee. I hope you find this offer interesting and I look forward to hearing from you. You are of course welcome to contact me if you have any questions or comments.

Kind regards,

John Christensen
GNESD Secretariat Head

UNEP
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Appendix A.

AMERICAN UNIVERSITY OF BEIRUT
FACULTY OF ENGINEERING AND ARCHITECTURE
ENERGY RESEARCH GROUP

Specialized Workshop on

Meeting the Energy Challenge of Lebanon

The Program

8:30 – 9:00 **Registration**

9:00 – 9:40 **Opening Session**

- Welcome
- ERG Coordinator Prof. N. Ghaddar, Faculty of Engineering and Architecture (FEA), AUB
- Dean of FEA, Prof. I. Hajj
- AUB Provost, Dr. P. Heath
- Minister of Energy and Water, H.E. M. A. Baydoun

9:40 – 10:00 **Keynote Speech**
Partnership between Government, Industry, and Universities for Improving Energy Efficiency and Utilization.
(Prof. B. Armaly, Program Manager US Department of Energy, Office of Science, USA)

10:00 – 11:15 **Experts Panel I: Energy Sector of Lebanon; Current Status**

Panel Chair: **H.E. M. Hajjar, Parliamentary Environment Committee**
Moderator: **Prof. S. Karaki, FEA, AUB**

- 10:00 – 10:15 Gas and electricity regional networking
(Mr. R. Baroudi, Advisor to the Minister, MoEW)
- 10:15 – 10:30 Environmental impacts of energy conversion
(Prof. F. Chaaban, FEA, AUB)

- 10:30 – 10:45 Financing national/regional energy projects
  (Dr. R. Kaidbey, Chairman First Europe Capital Group)
- 10:45 – 11:15 Discussion

11:15 – 11:45 Coffee Break

11:45 – 13:30 Experts Panel II: <u>Energy Policies for Lebanon</u>

Panel Chair: H.E. M. Kabbani, Chairman Parliamentary Committee for Energy, Transport, and Works
Moderator: Prof. M. El-Fadel, FEA, AUB

- 11:45 – 12:00 Power sector privatization
  (Mr. A. Rabbat, MoEW)
- 12:00 – 12:15 Towards a comprehensive national energy policy
  (Prof. R. Chedid, FEA, AUB)
- 12:15 – 12:30 Options and opportunities for facing the energy challenges in the ESCWA region
  (Dr. A. Hegazi, Chief of Energy Issues Section, ESCWA)
- 12:30 – 12:45 Public opinion as a factor in sustainable energy policies
  (Mr. N. Saab, MECTAT President, Editor- in - Chief Environment and Development magazine)
- 12:45 – 13:30 Discussion and recommendations

13:30 – 15:00 Lunch

Appendix B