

RMA

Energy Consultants

CAPABILITY STATEMENT



Resource Management Associates (Pvt) Ltd.

Sri Lanka.

February 2017

Capability Statement

Resource Management Associates (Pvt) Limited (RMA) was registered in Sri Lanka in March 1999. The Company's main focus is on the provision of consultancy services in the energy sector. Our specific market niche is in the areas of power generation, renewable energy development, electricity utility planning, energy management & conservation and analysis of energy policy issues. This stems from two main reasons – the long-standing experience of the partners of our company in the field of energy, and the increasing demand for this expertise globally.

Directors of the Company are Professional Engineers, each with over thirty years of experience in the energy sector of Sri Lanka, and extensive international exposure and experience. For specific tasks, RMA contracts outside experts from diverse fields of energy, engineering, and social sciences. To date, RMA has carried out numerous assignments focusing on:

- ⇒ Power sector policy, planning, economic and pricing
- ⇒ Due diligence on energy sector projects, particularly power plants
- ⇒ Project formulation in utility distribution systems
- ⇒ Services to lenders and investors in the power industry
- ⇒ Feasibility studies on thermal power plants
- ⇒ Feasibility studies on small hydro, biomass and wind power plants
- ⇒ Research and analysis of energy policy issues, national energy planning
- ⇒ Energy auditing in industries and commercial buildings
- ⇒ Design and implementation of energy conservation and management systems for the industry
- ⇒ Planning and implementation of national level energy surveys, development of provincial level energy databases
- ⇒ National level studies concerning the assessment of wind and small hydro resources
- ⇒ Aerodynamic and structural design of small wind turbines

RMA is based in Sri Lanka, and has extensive contacts with institutions and professionals working in the field of energy conversion and delivery, including Ceylon Electricity Board (CEB), Ministry of Power and Renewable Energy, Ministry of Petroleum Resources Development, Sri Lanka Sustainable Energy Authority (SEA), Public Utilities Commission of Sri Lanka (PUCSL), the Universities and the Sri Lanka Energy Managers Association (SLEMA).

Our recent clients in Sri Lanka include the Government of Sri Lanka, Public Utilities Commission of Sri Lanka, Sustainable Energy Authority of Sri Lanka, Ceylon Electricity Board, several foreign and local banks funding projects in the electricity industry, independent power producers using both conventional and non-conventional sources, prospective power industry investors and several major industrial groups.

Our recent international clients and associations include the World Bank, the Asian Development Bank (ADB), Japan International Cooperation Agency (JICA), Japan Bank for International Cooperation (JBIC), J-Power in Japan, Mitsubishi Research Institute in Japan, NEXANT Inc. of USA, Deloitte Emerging Markets Inc. of USA, National Renewable Energy Laboratories (NREL) of USA, MECADOS of Spain, Saudi Electric Company of Saudi Arabia, Hydro Tasmania in Australia and AECOM of New Zealand.

The Company Directors and staff currently serve have previously served on several committees and evaluation panels of the Government and professional bodies related to the energy sector.

Currently, we operate with a full-time staff of four senior consultants, two project engineers and two support staff attending to technical and secretarial functions. Our peripheral staff comprises senior civil, electrical, petroleum, production and mechanical engineers, economists, financial specialist and system analysts, and sociologists possessing varying expertise, who are called upon to perform specific tasks.

RMA's office is at

No. 27, Palmyrah Avenue,
Colombo 3,
SRI LANKA.

Phone +94-11-250 2030, 255 5533

Phone/fax +94-11-472 2893

e-mail: projects@rmaenergy.lk, Web: www.rmaenergy.lk

Key staff at RMA whose work directly relates to power sector planning and economics, renewable energy development, regulatory reform initiatives, and energy efficiency and demand side management are the following:

Dr Tilak Siyambalapitiya, BSc (Eng). Hon., PhD: Carries more than 35 years of experience in the energy sector of Sri Lanka, in the region and in east Africa. President, Sri Lanka Energy Managers Association (2004-6). Former Chief Engineer (Generation Planning) Ceylon Electricity Board (1989-94). Principal Engineer (Load Forecasting and Generation Planning) at Saudi Consolidated Electric Company (1994-1998). Since 1996, he has hands-on experience in conducting tariff studies for embedded generation in Sri Lanka and Tanzania, and continues to be engaged in studies on a wide range of issues related to pricing, grid interconnection and regulation of small to medium scale grid connected power plants. Has conducted numerous consulting studies since 1988 using planning tools, and for the calculation of long-run marginal cost of utilities for a World Bank study on beneficiary incidence of cross subsidies in electricity tariffs. Has served in various committees of the Government and the Ministry of Power and Renewable Energy on an honorary basis, the most relevant recent assignment being a member of Renewable Energy Policy Committee (2013). Additionally, has been a member of the committee to review power sector reforms (2005), the national energy policy committee (2004-2008) and the working group of renewable energy (2005-8); teaches energy efficiency, demand management and conservation to Masters Degree students; Contributing editor of Sri Lanka Energy Audit Manual 1999, 2000, 2013.

Mr Sunith Fernando, MSc: With over 40 years of experience in renewable energy development in Sri Lankan state, international and consulting agencies, Mr. Fernando's expertise in Mechanical Engineering is unique for Sri Lanka. He is highly experienced in wind, hydro and biomass resource assessment, power plant design, and has hands-on experience in a range of renewable energy project design and project management. His initial experience in the energy sector was in the implementation of the wind-based water pumping project for the Water Resources Board in Sri Lanka. He subsequently developed the wind resource assessment for the southern coastal belt, and went on to be the national consultant for the country-wide wind resource assessment study along with NREL of USA. He is equally experienced in small hydro resource assessment and in conceptual design. He has been a consultant to the World Bank, UNDP and ADB from time to time, and works full-time at RMA. He was the team leader to RMA's team of consultants to Sri Lanka's first commercial wind power plant commissioned in Puttalam in May 2010.

Mr Amila Wickramasinghe, BSc (Eng) Hon., MEcon: With more than thirteen years of experience in RMA, he is significantly involved in national and industrial level studies on energy efficiency and demand side management, power system analysis, renewable energy

and energy efficiency project development, economic and financial evaluations and project appraisal work conducted by RMA for international agencies, lending agencies, CEB and project developers. Being the principal author of Sri Lanka Energy Balance (an annual publication of Sri Lanka Sustainable Energy Authority), Mr Wickramasinghe offers a unique expertise with a combination of electrical engineering, finance and economics, and works full-time at RMA. He has worked on evaluation of the impacts of JICA-funded energy efficiency projects through macro-level analyses and customer surveys, and has hands-on experience in implementing energy audit findings in industries. He is experienced in modelling of hybrid renewable energy-based systems for stand-alone operation in mini-grids.

Mr Swetha Perera, MBA, BSc (Eng) Hons., PMP: With more than twelve years of experience in leading corporates (both Sri Lankan and foreign), Mr. Perera's expertise is in project management and financial and economic evaluation of infrastructure projects. Presently, as a full time employee of RMA, he participates in several national level studies on renewable energy planning and due diligence for loan packages from international funding agencies to the power sector of Sri Lanka, which are conducted by RMA, as a financial and economic analyst and a project management specialist. Mr. Perera has held project management responsibilities at various power sector development projects in areas of building power generation plants, rehabilitation of power plants, construction of new transmission lines and grid substations. He was also a member of the panel of authors of the Sri Lanka Energy Balance (an annual publication of Sri Lanka Sustainable Energy Authority) for several years.

Our external staff include a number of specialists in power system planning, transmission development, renewable energy development and financing.

Brief accounts of RMA's work on conventional and renewable power plants, electricity regulatory services, renewable energy, energy efficiency and demand side management are given in the following pages. A few similar tasks conducted in other countries are also stated.

PPTA - Consulting Services for Supervision and Support the Rural Electrification Road Map of Bangladesh Rural Electrification Board

Client: Asian Development Bank

Year: 2016-17

RMA provided the consultancy service of a distribution expert to the Asian Development Bank to support Bangladesh Rural Electrification Board in the implementation of roadmap of the Power System Expansion and Efficiency Improvement Project related to Distribution system upgrade, rehabilitation, extension and rural electrification. Reviewing of, master plan development process, preparatory activity for feeder level loss studies and reliability calculations and, requirement of manpower and equipment for development of improved Geographic Information System was carried out.

PPTA - Consulting Services for Mannar Wind Power Generation Project, Sri Lanka

Client: Asian Development Bank

Year: 2016-17

RMA partnered with Entura of Australia to provide project preparatory technical assistance to Ceylon Electricity Board, the state-owned electricity utility and the developer of the 100 MW Wind Power Project in Mannar Island, Sri Lanka in carrying out wind resource assessments, grid interconnection studies, conceptual technical design and preparing bid documents on implementation of the project on turn-key basis. In addition, social and environmental safeguard studies, and legal and economic appraisal of the project were carried out by RMA consultants on behalf of ADB.

PPTA - Consulting Services for the Preparation of Tranche 3 Project Under Bangladesh Power System Expansion and Efficiency Improvement Investment Program

Client: Asian Development Bank

Year: 2015-16

Working with e.Gen of Bangladesh, RMA was selected to provide consultancy services to the Asian Development Bank for the USD 425 million Tranche 3 of a Multi-tranche Financing Facility to be disbursed in Bangladesh from 2016, and a new USD 540 million loan for approval in 2016 for disbursements in Bangladesh. The project involved a diverse mix of generation, transmission, distribution and metering components, and RMA provided the team leadership, conducted the technical due diligence and social assessment of each component of the project proposed by the Government of Bangladesh.

PPTA – Supporting Electricity Supply Reliability Improvement Project

Client: Asian Development Bank

Year: 2015-16

RMA provided consultancy services to the Asian Development Bank for the USD 115 million loan to be disbursed from 2016 in Sri Lanka. The project involved a diverse mix of components including three renewable energy hybrid projects for islands off the northern Jaffna peninsula, a renewable energy based micro-grid pilot project, several transmission system reliability improvement projects and many distribution system expansion and reliability improvement projects. RMA provided the team leadership and the entire team of consultants, and conducted, technical, financial, economic, social and environmental evaluation of each component of the project proposed by the Government of Sri Lanka.

Study on Demand Drivers and Financial Implications 2015-2025

Client: Saudi Electric Company

Year: 2015

RMA provided consultancy services to the Saudi Electric Company of Kingdom of Saudi Arabia to develop DSM strategies that improve company profitability and bring economic benefits for the country. RMA carried out customer and demand analysis, forecast of electricity demand up to 2025 and assessment of viable DSM options in developing DSM strategies, assessment of financial implications of each DSM strategy on the financial statements of Saudi Electric Company and prepare economic, policy, tariff, DSM and renewable energy initiatives to meet the strategic objectives of Saudi Electric Company.

Capacity Building for Clean Energy Development – Part B: Preparation of Renewables Development and Wind Park Master Plans and Business Model for Wind Park

Client: Asian Development Bank

Year: 2013-14

RMA as the lead consultant, in partnership with Mercados Energy Markets India Private Limited, prepared the renewable energy development master plan for Sri Lanka, a wind park master plan for Mannar, and a business model for Mannar wind parks for the Ministry of Power & Energy of Sri Lanka with financial assistance provided by Asian Development Bank.

This was a comprehensive study on renewable energy resource availability, and on the technical limitations of the national grid which were causing barriers for integrating renewable resource-based power generation. RMA team developed the 15-year national master plan to accelerate power generation from renewable resources. The study included the development of a comprehensive Master Plan for wind power development in the Mannar district in northern Sri Lanka, and the development of a business model to attract investments for wind power development.

PPTA: Green Power Development and Energy Efficiency Improvement Investment Programme: Conducting Project due Diligence

Client: Asian Development Bank (in association with Deloitte (India) Ltd.)

Year: 2013-14

Working with Deloitte of India, RMA was selected to provide consultancy services to the Asian Development Bank for the USD 200 million Tranche 1 of a Multi-tranche Financing Facility to be disbursed in Sri Lanka from 2014. The project involved a diverse mix of generation, transmission, distribution and energy efficiency components, and RMA conducted the technical, economic and financial assessment of each component of the project proposed by the Government of Sri Lanka.

Sri Lanka Energy Audit Manual

Client: Honourary

Year: 2013

RMA hosted the editorial team of the new Sri Lanka Energy Audit Manual (4 volumes, 800 pages), to convert the contributions of individual authors into an attractive, easy to read manual. RMA energy efficiency experts reviewed the entire manual, and prepared the supplementary information, improved on the charts and diagrams, and prepared a camera-

ready version of the manual. This manual was subsequently used in three energy auditor training courses in Sri Lanka, to train 90 energy auditors. The manual continues to be widely used by energy efficiency specialists in Sri Lanka as a ready reference.

Wind and Solar Resource Assessment, Sri Lanka

Client: Sri Lanka Sustainable Energy Authority/Asian Development Bank

Year: 2012-13

The Asian Development Bank appointed RMA in December 2011 to assess the wind and solar potential and to map the resource in the north western and southern areas of Sri Lanka by way of on-site measurements and comprehensive mapping of the resource. This 18-month study developed investment-quality wind resource data to be used for the next phase of wind power development in Sri Lanka that would most likely develop 100 MW of wind capacity between 2014-2020. The solar resource assessment study conducted by RMA established investment grade information on the resource, which could be used by the Government and the private sector to develop power generation facilities in the future. RMA's sub-consultant for this study was Geonet of Germany.

Study on the Impacts of Wind Power, Interconnection Standards, and Electricity Market Integration

Client: Vietnam Electricity/International Copper Association

Year: 2012-13

Vietnam was planning to build 1000 MW of wind power capacity by year 2020. The country required a detailed study on (i) evaluation of technical impacts on the grid, (ii) technical standards for the interconnection, and (iii) the integration of wind power into the emerging competitive market. RMA was selected through a competitive process to conduct study (ii) and to develop a detailed review of (i) analysis tools and sample analyses on impacts of wind power on grids, and to develop case studies to understand how wind power may be included in the competitive pricing of electricity. Fielding a team of three experts, and two supporting experts, RMA conducted a comprehensive study of the Vietnam's technical standards for grid operations, and developed the draft technical standards. Based on the findings of a well attended workshop, RMA completed the technical standards, and also developed a detailed manual to be used both by the utility (EVN) and the prospective private sector developers.

PPTA: Clean Energy and Energy Efficiency Project: Conducting Project due Diligence

Client: Asian Development Bank (in association with Deloitte (India) Ltd.)

Year: 2012

Working with Deloitte of India, RMA was selected to provide consultancy services to the Asian Development Bank for the USD 140 million loan to be disbursed in Sri Lanka from 2013. The project involved a diverse mix of transmission, distribution and energy efficiency components, and RMA conducted the technical, economic and financial assessment of each component of the project proposed by the Government of Sri Lanka. Social and environmental safeguards documents in accordance with ADB guidelines, too, were required to be prepared.

Renewable Energy Development Program: Evaluation of Proposals for CBSF and FSSF

Client: Ministry of Industry and Trade, Vietnam/The World Bank

Year: 2012

The work included evaluation of proposals from Universities to support to develop new capacity building programs, and from companies to conduct feasibility studies on biomass and wind power plants.

RMA's lead consultant worked as the Team Leader (International) of the three member team, conducted a comprehensive evaluation of proposals received from six universities for initiating a new course for in-house and external students, on subjects and themes related to electricity production from renewable energy sources. Five proposals from companies for support for the conducting of feasibility studies on wind and biomass power plants were evaluated. Reviewed the evaluation methodology and comprehensively revised it, and completed the evaluation and the report. A workshop too was conducted for applicants to the round 2 of the feasibility study financing facility.

Power Sector Regulation in Maldives

Client: Maldives Energy Authority/The World Bank

Year: 2012

Working together with MECADOS Energy Markets, RMA provided technical and regulatory support to establish new rules and regulations, to streamline the licensing of electricity system operators, authorized persons to design and implement electricity distribution systems, labeling of appliances for energy efficiency, and to develop a system of evaluation for proposals from private entities to generate electricity in various islands.

India – Sri Lanka Grid Interconnection

Client: Government of Sri Lanka and Ceylon Electricity Board

Year: 2011

RMA was selected by the Government of Sri Lanka to conduct the economic, trade and legal components of the feasibility study on the planned interconnection between the electricity grids of Sri Lanka and India. Through a multidisciplinary team established for the purpose in association with Sri Lanka Institute of Policy Studies, RMA conducted extensive studies on the costs, routing options, trading options and business models for the grid interconnection, and modeled the expected transfers to derive the financial and economic and indicators of project feasibility.

Capacity Building for Power Sector Regulation in Sri Lanka

Client: ADB (in association with MECADOS Energy Markets of Spain)

Year: 2010-2011

This project was to build capacity with the Public Utilities Commission of Sri Lanka (PUCSL) and the Transmission/Distribution Licensees to implement tariff and other regulatory measures, since the implementation of the new regulatory regime under the Sri Lanka Electricity Act 2009. RMA provided counterpart services and hands-on support to PUCSL in the development and implementation of the Tariff Methodology, other allowed charges, revenue filing by licensees and analysis, support for conducting public consultations, development of end-use customer tariffs, development of codes for retail services, distribution and grid operations. The work also included the development of a tariff reform

and subsidy rebalancing road map to return the loss-making power industry to profitability by year 2015. RMA staff developed Distribution and Grid codes for Sri Lanka.

PPTA: Sri Lanka Sustainable Power Sector Support II Project

Client: ADB (in association with AECOM of New Zealand)

Year: 2010

This project preparatory technical assistance was to formulate the next ADB loan for the Sri Lanka Energy Sector, consisting of transmission, distribution, renewable energy and energy efficiency sub-projects, amounting to an estimated investment of USD 120 million. In association with AECOM of New Zealand, RMA provided expert assessment of transmission options and distribution strengthening requirements, rural electrification project formulation, requirements for distribution strengthening for the absorption of renewable energy to the national grid, and assessment of other renewable energy and energy efficiency interventions required. RMA successfully prepared the application for the Clean Energy Finance Partnership Facility of Japan/ADB, to finance a DSM pilot project in lighting, an appliance testing laboratory to launch the energy efficiency appliance labelling regulations, and for conducting energy audit training. In parallel, the ADB loan project included a credit line for the rehabilitation of micro-hydro projects in estates for grid connection under net metering rules recently announced by Sri Lanka.

The project formulated by the joint AECOM-RMA team has since been approved by ADB and is presently being implemented in Sri Lanka.

Project Development for Energy Efficiency Improvement

Client: J-Power, Japan

Year: 2010

In view of identifying and organising the candidate projects to be funded under the proposed Energy Efficiency Improvement Fund to be established in Sri Lanka with JICA assistance, JICA consultant, J-Power assigned RMA to develop a project pipeline. This assignment included reviewing of energy audit reports recently done in Sri Lanka, carrying out technical and financial review of these study findings, selecting promising projects for immediate development and processing three selected energy efficiency projects for development as show case projects.

SEIER Project, Vietnam

Client: The World Bank

Year: 2010

RMA's senior consultant conducted an analysis and developed the lessons learned on the Vietnam's System Efficiency Improvement, Equitization and Renewable (SEIER) project. The project aim was to develop or rehabilitate small community based renewable energy projects. Also conducted an assessment of the progress on the Small Power Development (SPD) program in Vietnam, identifying the gaps, information and regulatory requirements to further accelerate the SPD projects. Conducted a 10-day visit for a 15-member delegation from Vietnam to Sri Lanka, to study Sri Lanka's small power development program, with deep insight into the issues related to licensing, resource allocation, pricing, and technical issues of the program.

Mampuri Wind Power Plant

Client: Senok Wind Power

Year: 2008-10

RMA was the engineering consultant for the first commercial wind power plant in Sri Lanka, commissioned in May 2010. RMA supported the developer company with wind resource assessment studies, equipment selection, tariff studies, financial modeling of the project, review of project contracts, designing of electrical system including the transmission network and supervision during project execution.

The project was one of the four small power producer facilities approved under the new cost-based pricing policy of the Government, to encourage a diversity of renewable energy sources for electricity generation to reach the national target of 10% by 2015.

Energy Efficiency Improvement Promotion Project in Sri Lanka

Client: J-Power, Japan/JICA

Year: 2008, 2009 & 2010

As the consultant of JICA for its energy efficiency Technical Assistance (TA) program to the Sri Lankan Government, J-Power engaged RMA to carry out a baseline survey in 2008 at the commencement of the TA program. The survey included a national level energy intensity analysis, industrial benchmarking, appliance market energy efficiency status and the status of Energy Service Companies (ESCOs) operating in the country. Once the national level energy efficiency baseline was established, in 2009 and 2010, surveys and analyses were carried out to identify the effect of the specific activities carried out within the TA program to improve the energy efficiency of the country. In addition to these surveys and analyses, the impact of demand side management on the power system, especially on the system load curve, was studied with load forecast done for three years ahead.

Review of Sri Lanka Renewable Energy Pricing Policy

Client: Ministry of Power and Energy

Year: 2007-2010

Working on the invitation by the Ministry of Power and Energy in Sri Lanka (on an honorary basis), senior consultant of RMA played a lead role in a Working Group to review the policy of pricing small power developer inputs to the national grid. Conducted numerous scenario analyses under avoided cost-based and technology-based tariff options, and developed reports, analysed documents and presentations. Conducted many stakeholder seminars over 2007-9, including those for investors/developers, to discuss optional pricing policies and results of calculations. Analysed the tariff impacts on utility finances and impacts on customers. Sri Lanka has since moved, in 2008, from the previously avoided-cost based pricing policy to a technology-specific, cost-reflective, tiered tariff policy, and currently experiences an accelerated development of renewable energy-based small power developments

Sri Lanka Energy Efficiency Improvement Fund

Client: JICA Sri Lanka Office

Year: 2009

JICA assigned the development of the funding mechanism for a new Energy Efficiency Improvement Fund to assist the implementation of energy efficiency projects in (i) private industrial and commercial institutions (ii) government buildings, and (iii) appliances used in large scale by all electricity customers. RMA organised an interdisciplinary team of four specialists with hands-on, in-country experience in energy economics, engineering, banking and finance, and in government treasury operations, to develop the structure, eligibility criteria and the operating mechanism for this new credit line. A comprehensive financing plan was prepared for each focus area of the implementation.

Sri Lanka Power Sector Environmental Impacts Study

Client: The World Bank

Year: 2009

The study, conducted in association with ECA of UK, included analysis of energy demand and forecast future energy demand, conducting systems planning, analysis of coal linkages, analysis of financial implications of policy options, environmental impacts of power plant siting, environmental regulations and standards, definition of policy options and conducting scenario analysis, and conduct multi-attribute trade-off analysis.

Lighting Sri Lanka - Hambantota

Client: Ceylon Electricity Board

Year: 2008-09

In this project to serve 100% of the Hambantota district of Sri Lanka, RMA was selected by Ceylon Electricity Board to advise its staff on the flagship project of CEB on cost-optimal designs of medium and low voltage lines, application of coordinate-based systems to improve the conducting of surveys and data collection for areas yet to be electrified, to review and update the economic evaluation model used by CEB to rank the electrification projects in each village, to conduct a comprehensive baseline survey of a sample of 2000 households in the district, analyse the present status of reliability of the medium and low voltage networks, and to review designs of MV line routes and gantry designs.

Ex-post Evaluation of JICA funded projects

Client: Japan International Cooperation Agency (JICA)

Year: 2008-09

In association with ICNet of Tokyo Japan, RMA conducted ex-post evaluation of three JICA-funded projects completed in Sri Lanka over the past five years.

- (a) Power sector reform project
- (b) Medium voltage distribution project
- (c) Transmission and substations development project.

The work was conducted in accordance with the JICA rules laid out for such ex-post evaluation of projects. RMA conducted analysis of completed projects, examining their present status of operation and problems in operation and maintenance. RMA also developed the financial and economic models for (b) and (c) to assess the impacts of the investments on the economy and CEB

Access Improvement Project, Tanzania

Client: The World Bank/Ministry of Energy and Minerals

Year: 2007-09

RMA's senior consultants worked as a part of the international team to assist the Tanzania Ministry of Energy and Minerals (MEM) and the Energy and Water Utilities Regulatory Commission (EWURA) to develop and establish the pricing policy for grid connected and mini-grid based small power plants that use renewable energy, and to develop the technical guidelines for grid connection of embedded generators. Conducted several seminars and workshops in Tanzania for developers, utility engineers, ministry officials and regulatory staff, to discuss optional tariff setting mechanisms, and to present the proposed tariffs and technical guidelines. The policies, pricing methodology and technical guidelines developed by the RMA consultants have since been implemented in Tanzania.

Environmental Safeguards Analyses and Documentation

Client: Ceylon Electricity Board

Year: 2008

RMA was contracted by CEB to prepare the initial environmental examination documents for the upcoming National Grid Expansion Project to be financed by the Asian Development Bank. The project was for the upgrade of five grid substations to absorb small hydroelectric power generation, presently being rapidly developed by the private investors under the small power purchase scheme. While the small power development projects were being supported by the World Bank's RERED project, the ADB had come-up with finances to strengthen the grid to absorb power from such renewable sources. The transmission project also included upgrading of eight other grid substations, four new grid substations and five new transmission lines.

RMA prepared the IEE and the resettlement plan for CEB, which was then reviewed by ADB and accepted as compliant to ADB guidelines.

Consultancy Services to Lenders to 20 MW Diesel Power Plant in Jaffna Peninsula

Client: Union Bank, Sri Lanka

Year: 2005-08

The distribution network in Sri Lanka's Jaffna peninsula was separated from the main grid between 1995-2013. Two Independent Power Producers (IPPs) were procured to provide the supply to the isolated network, until the civil conflict ended in 2009, enabling re-connection to the main grid. RMA was contracted by the lenders to the one of the two IPPs (20 MW) to provide a comprehensive engineering and financial/economic due diligence on these diesel power plants. The services provided included analysis of the status of diesel generators, review of investor proposals for new investments to replace ageing and inefficient generating units, assessment of efficiency, monitoring of maintenance and fuel supply mechanism, etc.

Public Expenditure Review

Client: The World Bank

Year: 2007

RMA was assigned to conduct the power sector analysis of the Public Expenditure Review (PER), covering the following two areas in the electricity sector of Sri Lanka.

- (a) Subsidy beneficiary incidence analysis
- (b) Benchmarking the efficiency of Ceylon Electricity Board (CEB), the national electricity utility

The study examined the flow of subsidies into the electricity sector from the rest of the economy by way of direct grants, investment tax concessions, concessionary loans, rescheduled loans, debt moratorium and fuel tax concessions. The study then examined the flow of such direct and indirect subsidies to the customers, particularly those who were the most disadvantaged, by way of limited access to electricity. In conducting this study, the economic and financial costs of electricity was calculated using marginal costing and revenue requirement methods, and the subsidies as well as cross-subsidies to each class of customer were estimated for year 2005. The calculation of marginal costs were done using CEB's generation planning models, and the outputs of transmission and distribution planning models.

Another component of the study was the benchmarking of the performance of Ceylon Electricity Board. CEB has long been a successful state-owned utility, but since 1999, owing to its inability to implement cheaper generation projects, and the electricity prices not keeping pace with the increasing costs, CEB has been reporting losses. The study benchmarked the technical and financial performance of CEB against a more successful utility in the Asian region to learn the strengths and weaknesses of the approach of managing CEB, and set guidelines for its future operations.

Feasibility Study on a 5 MW Wood-fired Power Plant at Puttalam Cement Works

Client: Holcim (Lanka) Limited, Sri Lanka

Year: 2005

Holcim (Lanka) Limited owns and operates the only fully integrated Cement manufacturing plant in Sri Lanka. Holcim decided to develop a captive power plant to meet the critical loads in the factory thus enhancing the overall plant reliability level. After studying several fuel options in the pre-feasibility study conducted by RMA, Holcim requested RMA to conduct the feasibility study on a wood-fired power plant.

Based on a detailed analysis of the factory power and energy demand, RMA recommended a conventional steam power plant of capacity 5 MW producing 35 GWh of electricity annually. On the fuel supply side, RMA conducted comprehensive studies to select the most promising short rotation crops for wood fuel, potential for growing them in the region and developed the conceptual design of a wood fuel supply chain. Conceptual design of the power plant included fuel handling system, heat & mass balance, sizing and specifying the boiler, steam turbine, generator and associated auxiliaries. A comprehensive financial model was developed to evaluate the commercial feasibility of the project. RMA also addressed the socio-economic issues and assessed the project risks. The feasibility report has been accepted by Holcim.

Due Diligence Study on ACE Power Embilipitiya 100 MW Diesel Power Plant

Client: DEG, Germany

Year: 2005

The Embilipitiya Power Plant was a USD 60 million investment, with ACE Power (Pvt) Ltd of Sri Lanka and Caterpillar Power Generation Systems (CPGS) of USA holding equal shares. CPGS required to divest a portion of their equity, and DEG of Germany the investment arm of kfW required a due diligence study to be conducted about the technical and financial status of the power plant project.

Thus RMA was appointed as the consultant to Deutsche Investitions- und Entwicklungsgesellschaft mbH - Infrastructure Department – of Germany, to conduct a due diligence study on ACE Power Embilipitiya 100 MW power plant in Sri Lanka.

The study included the evaluation of the investment and its current market value, efficiency and status of maintenance, and a review of the power purchase agreement/dispatch prospects of the power plant. Based on the RMA recommendation, the project has now been divested.

PPTA: Formulation of the Network Expansion and Rural Electrification Project for Sri Lanka

Client: Asian Development Bank (in association with Hydro Tasmania (Australia)) Year: 2004-2005

RMA was selected by ADB to work in association with Hydro Tasmania of Australia, to formulate the bank's next investment project in Sri Lanka. The project was to strengthen the power sub-transmission network by establishing five grid substations, building new 33 kV lines and providing electricity services to a further 400 villages. The value of the project was targeted at USD 70 million.

The role of RMA was to conduct analysis of the performance of the existing MV network throughout the country, and identify weak areas by way of poor voltage regulation and reliability. RMA conducted extensive customer and network surveys, measurements and modelling, to identify the problems in the network and provide an initial overview to the ADB about the performance of projects previously funded by the bank. Thereafter, RMA liaised with the utility to critically review the technical performance of the MV network, conduct simulations and develop a long-list of projects. Through a screening process, the projects were prioritised and short-listed to be included in the project. The performance of each grid substation and MV line proposed was modeled and its performance was verified.

Lenders' Engineer for 250 MW Independent Power Plants (IPPs)

Client: Hatton National Bank, Sri Lanka

Years 1999-2000, 2003-2004

RMA was selected as the Lenders' Engineer by a consortium of Sri Lankan banks financing the construction of 250 MW of Independent Power Plant (IPP) capacity in four power plants in Sri Lanka. The projects were promoted by established Sri Lankan Companies. The power plants used diesel engines operated of heavy fuel.

The role of RMA was to conduct due diligence on all the technological aspects of the four power plants. RMA assisted the Banks to review the Power Purchase Agreement, Implementation Agreement and the Fuel Supply Agreement. RMA conducted supervision of the erection, testing and commissioning of the power plants on behalf of the Banks.

The total investment on the power plants were about 160 million US\$, of which about 110 million US\$ was financed through a syndicated long-term loan by the Consortium of Banks. The first power plant entered commercial operation in March 2002. The second power plant entered operations in April 2005. Power plants are operated by Wartsila of Finland under an Operation and Maintenance contract with ACE Power Generation and Caterpillar Power Generation Systems Ltd. The projects were developed on a Build, Own and Operate (BOO) basis under a 10-year Power Purchase Agreement with Ceylon Electricity Board.

Technical and Financial Proposal for a 20 MW Wind Power Plant in Narakkalliya, Sri Lanka

Client: Senok Trade Combine Limited, Sri Lanka

Year: 2002-03

In December 2002 Ceylon Electricity Board (CEB) requested proposals from the private sector for establishing a 20 MW wind power plant on Build, Own and Operate basis. Senok Trade Combine Limited, which was one of the short-listed companies, contracted RMA to

conduct necessary studies and prepare the technical and financial proposals for submission to CEB.

RMA conducted detailed wind data analysis using site-specific short-term wind measurements and long-term wind data from a nearby meteorological station to evaluate the site wind energy potential. Using the power curves of several wind turbine generators, RMA established the optimum machine and layout for the site. RMA also carried out the design of the 26 km long 33 kV transmission line and costing of civil works as per manufacturer's foundation designs.

Economic Feasibility of Expansion of Tashkent Power Plant in Uzbekistan

Client: Mitsubishi Research Institute, Japan.

Year: 2002

Uzbekistan had a mixed hydroelectric and thermal electricity generating system, dominated with natural gas. After experiencing a decline in the demand for electricity during early years of independence from the Soviet Union, the Uzbek system was experiencing a surge in demand once again. Some ageing thermal power plants had come to the end of their economic life, displaying poor fuel efficiency and reliability.

RMA was commissioned to conduct the economic evaluation of the proposal to expand the Tashkent Power Plant in Uzbekistan. The study was conducted for Mitsubishi Research Institute, Japan, as a part of their due diligence on behalf of the Japan Bank for International Cooperation (JBIC). JBIC was to finance the power plant expansion project.

In this study, the entire hydro-thermal power generating system of Uzbekistan was modelled to include existing and committed power generating facilities, and the expected growth in demand for electricity over the next 20 years. The proposed expansion for the Tashkent Power Plant was then included to examine whether there will be economic benefits to the system.

RMA conducted detailed financial analysis on the project and assisted the client to arrive at a competitive tariff.

Design and Development of a 200-Watt Wind Turbine for Battery Charging

Client: Intermediate Technology Development Group – Sri Lanka

Year: 2002

Nearly 40% of Sri Lankan households did not have access to electricity supply through the national grid. Many of them were located in rural areas where the grid extension was often found to be uneconomical. This was primarily due to the low energy demand in most rural households coupled with the high cost of extending and maintaining the grid supply lines.

In 1998, Intermediate Technology Development Group (ITDG) launched a project to develop a small battery charging wind generator, which could cater to the needs of rural households. Design and development of this machine was contracted to RMA.

In June 2000, the first prototype was fabricated and subjected to a rapid assessment of the performance of the rotor and speed control system using the technique of Controlled Velocity Testing (CVT). This was performed in Ussangoda, a flat open tract of land overlooking the southern coast. A wind data logger and digital power monitoring meters were used to collect the data. The system consisted of a two bladed wind turbine that drives the 200W Permanent Magnet Generator (PMG) of "air gap type". AC supply from the PMG was

rectified and used to charge the battery. The battery supplied AC electricity to the household through a 400W inverter.

The prototype machine is now running in a southern village called Andarawewa, Once the testing phase is completed, RMA will develop the production model and train local workshops in the manufacture of this wind turbine.

Pricing of Electricity from Independent Power Plants in South Asia

Client: US Agency for International Development

Year: 2001-02

RMA was selected by US Agency for International Development and Deloitte, Inc. of USA to conduct a study on the pricing of electricity produced from Independent Power Plants (IPP) in Sri Lanka. This was part of a study of 20 private power plants in South Asia, to ascertain the competitiveness of tariffs offered by IPPs in relation to utility/Government projects.

Three IPPs in Sri Lanka who agreed to participate in the study were examined in detail for their investments, operating costs and tariffs. Similarly three Government/Ceylon Electricity Board projects of comparative technology were analysed to calculate the off-take price and any adjustments required to represent any concessions received.

The study included the development of financial models for each selected private or government project, technical evaluation to assess their operating performance, making adjustments to account for concessions, and arriving at an adjusted levelised price.

Wind Energy Resources Assessment in the North Western Coastal Belt and Knuckles Range

Client: UNDP/Ceylon Electricity Board, Sri Lanka

Year: 2000-01

Due to its geographical location in the Indian Ocean, several regions in Sri Lanka experience strong to moderate winds during the Southwest and North-East Monsoons. In 1988, the Ceylon Electricity Board (CEB) decided to investigate the potential for use of wind energy for large scale electricity generation. The three-year study covered the south-eastern lowlands, and on completion of it, CEB installed a 3 MW pilot wind power plant for research and demonstration purposes.

CEB extended its wind resource studies to the north-western coastal region and Knuckles mountain range with technical and financial support from UNDP/GEF. CEB selected RMA as the National Consultant for the project due to RMA's in-house expertise in this field.

Scope of the assignment included,

- ⇒ Site survey for a network of wind measuring stations over flat land and complex terrain.
- ⇒ Supervision of wind mast installation.
- ⇒ Wind data processing.
- ⇒ Data analysis and reporting

Integration of Wind Energy into the Electrification Networks in Outer Islands in Maldives

Client: Asian Development Bank, Manila.

Year: 2001

All outer islands in the Maldives were electrified using diesel-based power plants. Cost of imported fuel and its transportation to outer islands accounted for a significant component of the local electricity tariff. Asian Development Bank (ADB), which was studying the overall development of the outer island electrification systems in the Maldives, contracted RMA to study the feasibility of integrating wind generators into island electricity networks.

RMA expert visited some of the potential islands along with the ADB Team and had extensive discussions with the local power system operators on this subject. Main difficulty experienced by RMA in this study was the lack of good quality wind data for assessment of the wind energy potential in islands. RMA accessed regional wind data and compared them with locally available data to make preliminary estimates of the wind power plant performance in the island wind climate. Subsequently, RMA assisted ADB in the preparation of a Project Brief for submission to the Global Environmental Facility (GEF) seeking grant funding for a wind and solar-based pilot project in the Maldives.

Design of a 220 kW Small Hydro Power Plant for the Kissizi Hospital in Southwest Uganda

Client: The World Bank

Year: 2001

The Government of Uganda had proposed “Energy for Rural Transformation Programme” for World Bank assistance. The key objectives of this programme were to improve the rural quality of life and facilitate significant rural non-farm income by accelerating rural electrification using Uganda’s indigenous, renewable energy resources.

Expansion of the hydroelectric capacity of the small hydro plant in Kisizi Hospital was an investment that fell under the sub-component 2 of this programme. Kisizi Hospital, which was associated with the Church of Uganda, was located in the Rukungiri District in Southwest Uganda. The hospital had a strong presence in the area, with a campus of some 50 buildings from which a wide variety of community services were offered in support of their mission to address the social and economic, as well as the spiritual and curative needs of the local community.

The hospital had owned and operated a 60kW micro hydro plant since 1986 for its own use and was interested in expanding its capacity utilizing the full hydro potential of the river Rusoma. The World Bank contracted RMA to carry out the design of this plant. Work done by RMA include:

- ⇒ Hydrology analysis of river Rusoma.
- ⇒ Redesign of the existing weir, intake and channel to handle 1000 l/s design flow.
- ⇒ Sizing of the desilting tank.
- ⇒ Hydraulic and structural design of the 700 mm penstock
- ⇒ Writing technical specifications for electro-mechanical equipment.
- ⇒ Overall project costing.

Technical Standards for Grid Interconnection of Embedded Power Plants

Client: The World Bank/Ceylon Electricity Board, Sri Lanka

Year: 2000

RMA was selected by the World Bank and Ceylon Electricity Board (CEB, the National Electricity Utility in Sri Lanka) to prepare a Guide for grid interconnection of small power

plants embedded in the distribution system of Sri Lanka. RMA provided the Consulting Services to this project jointly with DULAS Ltd. of UK.

Connection of relatively small, embedded power plants to the CEB network commenced in the mid-1990s. These embedded power plants are mostly built, owned and operated by non-utility Companies and individuals. Most of these were small hydroelectric plants, with a few Combined Heat and Power plants also in operation. There were purpose-built, investor-owned power plants as well as those with a captive load, such as a tea factory.

The interconnection agreement between the CEB and the Generator is based on a Power Purchase Agreement, which has been standardised by the CEB. The technical requirements for the safety and protection of equipment used for the interconnection were guided by the G/59 Technical Recommendations published by the Electricity Association of the UK. There was a need to streamline the design, testing and commissioning of the interconnection of embedded power plants with the Grid to match specific situations in Sri Lanka.

RMA in association with DULAS Ltd. of UK, developed the Guide Book, after studying the specific requirements and characteristics of both the CEB grid and the small power plants. Services provided to CEB also included two Training Courses conducted by RMA/DULAS.

Study on Small Power Purchase Tariffs, Sri Lanka

Client: The World Bank / DFCC Bank, Sri Lanka

Year: 2000

The World Bank initiated the Energy Services Delivery (ESD) project in Sri Lanka to support the development of renewable energy-based power generation. ESD project provided substantial amount of financing for small hydropower plants operating in the grid-connected mode selling electricity to the national utility – Ceylon Electricity Board (CEB) on a standardised power purchase agreement.

The purchase tariff is calculated and announced by CEB at the beginning of each year. This tariff calculation is based on the principle of avoided costs to the utility as result of inputs to the grid from small power plants.

Concerns had been expressed about the methodology adopted by CEB to calculate the tariff, and the suitability of the principle of avoided costs itself. Furthermore, small power developers had claimed that they too should receive a capacity charge similar to what is paid to the large independent power producers. Views had also been expressed about the lower levels of the tariff, which was not adequately stimulating a rapid development of the remaining small hydroelectric sites and other renewable sources of energy.

The World Bank under the ESD project assigned RMA to conduct a study to analyse and propose improvements to the present method of CEB tariff calculations, and to examine whether capacity credits accrue to the utility with the embedded generators.

The work extensively used CEB's WASP and METRO planning models.

Feasibility Studies on Small Hydro Power Development

Various clients

Year: 1999 to date

Harnessing of small hydropower for industrial applications was started in Sri Lanka as early as the late nineteenth century. Over 500 such plants provided the motive power required for the expanding tea industry during the colonial era. With the expansion of the national

electricity grid, these plants started fading away from the industrial scene beginning around 1950.

In 1992, Ceylon Electricity Board authorised the grid-connected operation of small hydropower plants with an attractive buy-back price. This marked the resurgence of small hydropower development in Sri Lanka creating a new private sector power industry. Small hydropower development has been gathering momentum since then, adding nearly 442 MW to the system to date.

RMA provided consulting services to a number of small hydropower developers in preparing feasibility studies and engineering designs. Following are some of the schemes where RMA participated as the Consultant.

⇒ Arslena Mini Hydro	900 kW
⇒ Kolapathana Mini Hydro	600 kW
⇒ Kakunagahadola Mini Hydro	550 kW
⇒ Delmar Mini Hydro	320 kW

RMA served as the Bank's Consultant to the Commercial Bank of Ceylon who financed the 1.2 MW Watawala Mini Hydro plant.

Training of Engineers in the Design of Small Hydro Power Plants

Client: Intermediate Technology Development Group – Sri Lanka

Year: 1999

Development of small hydropower in Sri Lanka dates back to early part of the twentieth century. It is estimated that nearly five hundred small hydro plants with a combined capacity of about 10 MW had been operating in the plantation sector in Sri Lanka during the first half of the century.

In 1993 CEB authorized the grid connection of small hydro plants, and since then, small hydro development started gathering momentum as a newly emerging investment opportunity for the private power sector. Total small hydro potential in Sri Lanka was estimated as 200MW to 250MW.

For the long term sustainability of small hydro development, it was necessary to build the local engineering capacity in such areas as, feasibility studies, design, & construction and O&M etc. Intermediate Technology Development Group (ITDG) – Sri Lanka, a non-governmental organization with international reputation, realized this need and carried out several national training courses to build the local capacity in small hydro power.

In 1999, UNDP/GEF funding was made available by the Ministry of Irrigation & Power to ITDG to conduct two more training courses in this sector. ITDG selected RMA to design and implement these two courses.

A Selection of Other studies in the Energy Sector

Study: Energy Efficiency Improvement in the Tea Industry

Client: Maskeliya Plantations Limited, Sri Lanka

Energy Efficiency in the Sri Lanka Ceramic Cluster

Client: US Agency for International Development

Survey and Analysis of Household Energy Consumption

Client: Intermediate Technology Development Group, Sri Lanka

Energy in the Street Food Sector

Client: Intermediate Technology Development Group, Sri Lanka

Feasibility Study for an Energy Efficiency Improvement Fund

Client: Japan Bank for International Cooperation, in association with J-Power, Japan

In-Country Coordination Support in Implementing Renewable Energy Projects

Client: United States Agency for International Development (USAID), in association with National Renewable Energy Laboratory (NREL), USA