

## Focus Area 6 : Energy

### Introduction

The whole world faces a daunting array of energy and environment related challenges with the increasing demand for products and services. Energy is the main driver of the development and the increasing energy demand is catered primarily by fossil fuels. Depleting resources of energy are responsible for much spoken environmental impacts.

The considerable growth in energy demand has number of implications both regionally and globally. In the coming decades the energy demand is expected to increase steadily among the developing countries. Although there is a pronounced shift away from nonrenewable towards natural gas and renewable; the energy demand barely rises in developing countries.

The international organizations on climate change highlights that the emission of Green House Gases (GHG) have grown at a higher rate, despite the variety of existing policy efforts and frameworks. Most of the governments are addressing climate change in the context of other national priorities. The policies to mitigate GHG emissions are extremely complex and arise in the context of many different integrated models which requires a diverse portfolio of policies, institutions and technologies. Integrated models identify three categories of energy system related mitigation measures; the de-carbonization of energy supply sector, final energy demand reductions, and the switch to low-carbon fuels. The final energy demand reduction targets are achieved through energy efficiency improvements,

conservation and management where most of the countries have higher emphasis on energy efficiency than renewable energy (RE). The main sources of energy in Sri Lanka are renewables as biomass catering for thermal energy and large hydro for electricity generation. Socio-economic

growth directly influences the demand for energy. The heavy necessity of imported fossil fuels affects directly on foreign reserves, as well as the economic development and the social & political stability of the country.

As solutions to the energy security, environmental sustainability and inclusive social, economic growth which are the challenges for a sustainable development; less energy intensive economic development has been proposed. Covering the above three challenges Sri Lanka has set targets of achieving electricity generation using new RE, energy saving and reach 100% household which is 96% at present, thus contributing to the national goal of “Electricity for All at All Time” by 2020. With the increasing demand for energy to provide for the country’s economic and social development, total primary energy demand is expected to increase to about 15,000 kTOE by the year 2020 at an average annual growth rate of about 3%.

Over the next 20 year period, as the country’s GDP and the population are expected to increase, the final energy demand is projected to increase at an annual rate of 1.9%. Moreover, the other sectors including residential, commercial, agriculture and fishery will increase slowly while transport and industry demand will increase at a significant rate.

Although the economical exploitable quantity is yet to be estimated; Sri Lanka possesses with several energy minerals for nuclear energy. Moreover, Mannar Basin is believed to hold more than 1 billion barrels of oil which needs an additional drilling to determine if the discovery was commercial. Sri Lanka is blessed with several energy resources including Biomass, hydro, solar and wind while Biomass is the main source of energy which contributes 43.5% of the primary energy supply. Other sources such as geothermal, ocean thermal and ocean wave are yet to be characterized and exploited.

As the interest in bioenergy has been renewed as an alternative for fossils, the government has declared plantation crops such as Gliricidia and some innovative plantation practices are being tested. Moreover, as an alternative to LPG, several innovative biomass cook-stoves for households are already available in the commercial market. Furthermore, 7000 biogas digesters are in operation mainly in suburbs and rural areas. Conversion of Municipal Solid Waste (MSW) into energy is still have not materialized due to some technological and lack of awareness issues.

Large hydro power with a total installed capacity of about 1360 MW is the main electricity generation renewable source and grid electricity generation is based on the remaining sources namely small hydro, wind, biomass and solar which is primarily promoted through the projects of capacity not greater than 10 MW. Presently a total of 384MW has been commissioned.

Nevertheless; the exploitation of RE resources (especially wind and solar) is limited by several techno-economic factors including constraints in national

grid in absorbing RE based electricity, lack of dynamic modeling , lack of local capacity for manufacture, lack of R&D efforts and higher initial cost of new REs.

The energy management in the road transport sector is another key sector having energy challenges. Energy intensity in the transport sector is steadily increases with the increase of individual vehicles in the fleet when compared to the public transport. Among the total number of 4 million vehicles on the roads, majority of 52% is motorcycles and then three-wheelers and cars accordingly while 1% represents busses.

In conclusion, research and development will play a key role in making the required immediate interventions to manage the energy sector in Sri Lanka. In this study, the evaluation and prioritization methodology of R&D programs and interventions are carried out in line with Sustainable Assessment of Technology (SAT).

## Sub Areas, Issues and Relevant Interventions

Table 1: Sub Areas and Justifications

Sub Areas/Sector	Justifications
<b>(A) Indigenous Energy Resources and Technologies (Renewables, Nuclear, Fossil)</b>	
<b>1) Resource Assessments of indigenous energy resources (RE, Fossil, Nuclear)</b>	Comprehensive information on energy resource maps/inventories is required, not only for energy planning at national / local levels and setting realistic targets, but also for identifying suitable locations for development of individual projects for optimum exploitation of resources and prioritizing them.
<b>2) RE Technology Development for Electricity</b>	Electricity is the most versatile and cleaner energy carrier for the consumers and the use of RE for electricity generation could contribute not only for the energy security, self-generation and rural electrification but also to mitigate adverse environment effects associated with the use of conventional fossil fuels.
<b>3) RE Technology Development for Thermal Energy</b>	Although thermal energy is the main end-use application in domestic, commercial and industrial sectors, and wide variety of improved RE resource-technology and process options are available as better alternative to conventional systems, technology transfer and adaptation are yet to reach acceptable level. The deployment of RE technologies for thermal energy applications would help local industries to reduce the risk of price shocks due to both fuel price increase and currency depreciation when imported fuels are used as well as supply disruption risks and costs, and thereby enhance market competitiveness.
<b>4) RE Technology Development for Transport</b>	Transport is the key sectors affecting the importation of fossil oil, and any target in fossil oil saving would require interventions in this sector. Development of RE based transport systems is yet to be considered seriously in the country, though many initiatives and best practices could be seen in several other countries.
<b>5) RE for other energy uses and non-energy services</b>	In addition to conventional energy applications, RE (being local resource) could provide opportunities for much wider areas of interventions including generation of multiple products (energy, fuel, material – in case of biomass) or energy services (co-generation, tri-generation), non-energy services (e.g. water), etc., leading to more productive and efficient systems. Such approaches are receiving more attentions, particularly with new economic development models (circular economy).

Sub Areas/Sector	Justifications
<b>6) Resource Development</b>	Development of RE sector depends critically on availability and sustainable supply of the resources (particularly biomass/biofuels and hydro), but the emphasis on this aspect is not visible in the country, resulting deterioration/depletion of the resources for the sake of other developments. Interventions for resource enhancement are required for the long term sustainability, and even enhancement of the resource base.
<b>7) Effective energy storage systems</b>	For small scale applications, lack of back-up power for uninterruptable power supply is a challenge for wind and solar electricity generation, for which effective energy storage becomes a necessity. In case of grid electricity generation, the demand pattern (with evening peak and late-night valley) poses limits for absorbability of renewable energy resources, thus requiring a storage mechanism. Hence, effective energy storage systems could remove some key technology barriers for the promotion of RE.
<b>8) National Electricity Infrastructure / Grid Architectures</b>	Although abundantly available, wind and solar energy generation experience intermittency, a combination of non-controllable variability and partial unpredictability, and location dependency, together with demand fluctuations create distinct challenges. Weather and resource forecasting, modelling & controlling facilities in optimum dispatch planning are required to improve this.
<b>(B) Energy Efficiency Improvements, Conservation &amp; Management</b>	
<b>9) Domestic Sector</b>	Ever increasing cost of energy is affecting the quality of life of majority of the population, while significant energy wastage could be seen in the domestic sector due to the use of inefficient appliances as well as use of appliances inefficiently. Further, RE-based in-situ energy generation (eg. solar PV, biogas) is quite possible in many part of the country. Therefore, energy efficiency improvements, conservation and management become vital in coping up with household energy budget.
<b>10) Commercial and Industrial Sectors</b>	Energy efficiency of processes, plants & machinery, buildings, particularly life-cycle-analysis; RE options and waste management are not considered adequately in the development and management of businesses, industries and commercial establishments leading to energy intensive products / processes. Improved energy efficiency or reduced energy intensity is a fundamental requirement for enhancing market competitiveness.

Sub Areas/Sector	Justifications
<b>11) Power Sector</b>	Energy efficiency improvements and loss reduction in generation, transmission and distribution of electricity are vital for the improved and satisfactory power sector performance (technical and financial), benefits of which can be readily transferable to all sections of the economy.
<b>12) Transport Sector</b>	Transport sector is almost entirely depend on imported fossil fuels, and energy efficiency / fuel economy aspect of the transport sectors has not been properly dealt with, resulting over-burden in relation to energy/fuel consumption and thereby to development sustenance. Degradation of mass transport systems, intermodal and non-motorized transports together with increased in private vehicle has led to high congestion and loss of resources. Immediate interventions are required to mitigate the adverse effects on the economy and environment arising from transport sector performance.
<b>13) Energy Efficient Zones / Communities</b>	More efficient use of energy and exploitation of RE resources are the basic approaches of sustainable energy driven economy, for which the power of community could be used in adopting holistic approach where public and private sectors make a collective commitment and work towards inclusive socio-economic development.
<b>14) Smart metering</b>	With the developments in new/advanced technologies (particularly ICT) and novel concepts such as smart metering and dynamic pricing, it is increasingly become evident, especially in developed countries, that the end-use sector electricity demand could be managed by introduction of such technology / process advancements.

**Table 2: Issues/ Problems, R&D Needs and Relevant Interventions**

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
<b>(A) Indigenous Energy Resources and Technologies (Renewables, Nuclear, Fossil)</b>			
<b>1) Resource Assessments of indigenous energy resources</b>	I) Lack or unavailability of indigenous energy resource maps/inventories, affecting energy planning at national and local levels	i) Development of small hydro, wind, solar and biomass resource maps, inventories, road maps	<p><b>Policy Studies</b> Policy interventions for RE Road map with long term targets</p> <p><b>Pure &amp; Applied Research</b> Development of RE resource maps, inventory and roadmaps</p> <p><b>Innovation</b> Development of innovative resource mapping techniques</p> <p><b>Information and Communication Technologies</b> Integration of ICT for resource measurements and mappings</p> <p><b>Capacity Building</b> Capacity building on modelling/simulation</p> <p><b>Popularization</b> Dissemination of information on RE resource</p>
	II) Inadequacy of information on resource availability for the development of road-maps and set realistic targets	ii) Exploration of fossil fuels (NG / Oil) – technical and economic potentials	<p><b>Innovation</b> Develop a plan for exploration of fossil fuels (NG / Oil) – technical and economic potentials</p>
<b>2) RE Technology Development for Electricity Generation</b>	I) Limited emphasis on optimum exploitation of indigenous resources through technology developments	i) Small hydropower developments: design of low head SHP, micro-hydro, pico-hydro, local manufacture of turbine and inverters	<p><b>Innovation</b> Develop small hydropower systems</p>

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
	II) Lack of inventions and innovations in technology development and adaptation in the power sector	ii) Development of wind energy systems locally: design and manufacture of blades, off-grid wind turbines, PMGs, inverters.	<b>Innovation</b> Develop wind energy systems locally
<b>3) RE Technology Development for Thermal Energy Applications</b>	I) Much emphasis is given for improved / cleaner cooking fuels & technologies (e.g. due to indoor air pollution) internationally, yet the conventional biomass technologies are still being practiced by the local majority, and the use of efficient technologies and cleaner sources such as liquid biofuels and biogas is still not significant	i) Design and commercialization of improved/efficient biomass cookstoves – ICSs (both direct combustion and gasification for domestic and institutional applications)	<b>Popularization</b> Commercialization of improved/efficient biomass cookstoves
	II) There are many technology enhancements in renewable resource based thermal energy systems internationally, but technology transfer and adaptation are yet to reach acceptable level locally	ii) Development and dissemination of biomass direct combustion furnaces and kilns for high temperature industrial applications (including fuel-switching of conventional fossils)	<b>Pure &amp; Applied Research</b> Development of technologies for fuel preparation, conversion and emission control  <b>Innovation</b> Development of Innovative technologies and processes  <b>Information and Communication Technologies</b> Integration of ICT for resource measurements and mappings  <b>Capacity Building</b> Capacity building on modelling/simulation  <b>Popularization</b> Dissemination of information on RE resource

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
	<p>III) Potential use of RE resources and technologies for processing of agricultural and food products has not been explored adequately, affecting the profitability in the sectors.</p>	<p>iii) Development and dissemination of solar air collectors for low temperature industrial applications (e.g. drying / dehydration of agricultural and food products)</p>	<p><b>Pure &amp; Applied Research</b> Design &amp; Optimization of solar air heaters for different products</p> <p><b>Innovation</b> Introduction of innovative concepts / configurations for better performances of solar dryers</p> <p><b>Indigenous knowledge &amp; Intellectual Property Rights</b> Study on traditional knowledge / best practices on solar drying technologies</p> <p><b>Testing, standardization &amp; Accreditation</b> Development of code of practice for solar dryers</p> <p><b>Capacity Building</b> Training on design, fabrication and operation of solar dryers</p> <p><b>Popularization</b> Dissemination of information / technology demonstrations</p>
		<p>iv) Development and dissemination of biomass driers (direct / indirect) for low temperature industrial applications (e.g. drying / dehydration of agricultural and food products)</p>	<p><b>Pure &amp; Applied Research</b> Design &amp; optimization of biomass driers for different products</p> <p><b>Innovation</b> Introduction of innovative concepts / configurations for better performances of biomass dryers</p>



Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
			<p><b>Indigenous knowledge &amp; Intellectual Property Rights</b> Study on traditional knowledge / best practices on biomass based drying technologies</p> <p><b>Testing, standardization &amp; Accreditation</b> Development of code of practice for biomass dryers</p> <p><b>Capacity Building</b> Training on design, fabrication and operation of biomass dryers</p> <p><b>Popularization</b> Dissemination of information / technology demonstrations</p>
<p><b>4) RE Technology Development for Transport Applications</b></p>	<p>I) Transport is the most vulnerable sector as far as dependence on imported fossil fuel is considered, thus affecting the energy security</p> <p>II) Although there is an increasing emphasis on development of alternative transport fuels / technologies, very little emphasis is given on these aspects in transport planning</p> <p>III) No technology road map / targets in the transport sector (lack of integration of research outcomes for policy making)</p>	<p>i) Development and promotion of biofuels for transport applications: Biodiesel - feedstock, production, processing and commercialization (blending)</p>	<p><b>Innovation</b> Develop biofuels for transport applications: Biodiesel</p>
		<p>ii) Development and promotion of biofuels for transport applications: Ethanol – feedstock, production, processing and commercialization (blending)</p>	<p><b>Innovation</b> Develop biofuels for transport applications: Ethanol</p>
		<p>iii) Development and promotion of biofuels for transport applications: Biogas – feedstock, biogas cleaning, storage/ distribution</p>	<p><b>Innovation</b> Develop biofuels for transport applications: Biogas</p>

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
		iv) Development and promotion of electric/hybrid vehicles: Solar, wind, small-hydroelectricity based charging stations and networks	<b>Innovation</b> Develop electric/hybrid vehicles: Solar, wind, small-hydroelectricity based charging stations and networks
5) RE for other energy uses and non-energy services	l) Potential of advanced energy systems (e.g. co-generation, tri-generation, thermo-electric generation) is largely overlooked, hindering further developments of the RE sector	i) Design and dissemination of modern high efficient biomass energy conversion technologies for commercial and industrial applications (e.g. cogeneration, tri-generation)	<b>Pure &amp; Applied Research</b> Research on modern high efficient biomass energy conversion technologies for commercial and industrial applications
6) Indigenous Resource Development	l) Development of RE sector depends critically on availability and sustainable supply of resources, but the emphasis on this aspect is not visible	i) Development of fuel-wood plantations and management systems (species, plantation practices - intercropping / under-cropping)	<b>Policy Studies</b> Policy interventions on land-use planning for promotion of biomass  <b>Pure &amp; Applied Research</b> Development of sustainable plantation management techniques with high productivity  <b>Innovation</b> Innovations in plantation management for optimum economic output <b>Biotechnology</b> Developments in bio technology for fuelwood plantation  <b>Indigenous knowledge &amp; Intellectual Property Rights</b> Exploration and adaptation of indigenous plantation management techniques

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
			<p><b>Testing, standardization &amp; Accreditation</b> Development of standards for sustainability criteria for bioenergy</p> <p><b>Capacity Building</b> Training on sustainable plantation management techniques</p> <p><b>Popularization</b> Popularization of sustainable fuelwood plantation technique</p>
<b>7) Effective energy storage systems</b>	<p>I) Electricity demand pattern of the national grid (with evening peak and late-night valley) poses limits for absorbability of renewable energy resources, especially wind and solar, in spite of high availability</p> <p>II) Lack of low cost and efficient options for storing electricity when production exceeds demand and using it during peak-demand periods</p>	<p>i) Feasibility study and design of pump storage systems for large-scale grid electricity storage (both dedicated reservoirs and modified existing reservoir systems)</p> <p>ii) Development of advanced battery technologies for medium and small scale grid energy storage (Ni-Cd, Lithium-ion, Sodium-sulphur, Sodium-Ion)</p>	<p><b>Pure &amp; Applied Research</b> Conduct a feasibility study and design of pump storage systems for large-scale grid electricity storage</p> <p><b>Innovation</b> Develop advanced battery technologies for medium and small scale grid energy storage</p>
<b>8) National Electricity Infrastructure / Grid Architectures</b>	<p>I) Although abundantly available, wind and solar electricity generation experience intermittency, a combination of non-controllable variability and partial unpredictability, and location dependency, together with demand fluctuations create distinct challenges</p>	<p>i) Design and optimization of national grid with mix of central and distributed generation system for grid integration of REs</p> <p>ii) Development of advanced electricity generation and supply &amp; demand forecasting tools for optimum grid integration of REs</p> <p>iii) Design of dynamic modelling tools for optimal electricity dispatch for grid integration of REs</p>	<p><b>Pure &amp; Applied Research</b> Conduct research on Design and optimization of national grid with mix of central and distributed generation system for grid integration of Res</p> <p><b>Pure &amp; Applied Research</b> Conduct research on advanced electricity generation and supply &amp; demand forecasting tools for optimum grid integration of REs</p> <p><b>Pure &amp; Applied Research</b> Development of dynamic modelling tools for optimum electricity dispatch for grid integration of RE</p>

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
			<p><b>Innovation</b> Introduction of innovative concepts for optimum electricity dispatch in grid-integration of RE</p> <p><b>Information and Communication Technologies</b> Effective use of ICT for optimum electricity dispatch in grid-integration of RE</p> <p><b>Capacity Building</b> Training on dynamic modelling and optimum electricity dispatch</p>
<b>(B) Energy efficiency improvements, conservation &amp; management</b>			
<b>9) Energy Conservation in the Domestic Sector</b>	I) Lack of local development of energy efficient appliances	i) Design, manufacture and commercialization of energy efficient lighting products and fixtures locally	<p><b>Innovation</b> Develop strategies to design, manufacture and commercialization of energy efficient lighting products and fixtures locally</p>
		ii) Design, manufacture and commercialization of energy efficient LPG stoves and burners	<p><b>Innovation</b> Experiment the design, manufacture and commercialization of energy efficient LPG stoves and burners</p>
	II) Very little control over marketing of energy inefficient household appliances	iii) Development on enforcement of energy efficiency labelling of appliances in the domestic sector (Lamps, A/Cs, Iron, Cookers, Refrigerators, Pumps, Washing M/C)	<p><b>Policy Studies</b> Development of energy labelling regulations</p> <p><b>Innovation</b> Formation of innovative criteria for the estimation of energy performance of appliances</p> <p><b>Testing, standardization &amp; Accreditation</b> Development of testing standards and accreditation of testing facilities</p>

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
			<p><b>Capacity Building</b> Training on energy labelling testing procedures</p> <p><b>Popularization</b> Popularization of energy efficient appliances among the entire community</p>
<p><b>10) Energy Conservation in the Commercial and Industrial Sectors</b></p>	<p>I) Energy efficiency of processes, plants &amp; machinery, particularly life-cycle-analysis, are not considered adequately in the development of businesses, industries and commercial establishments leading to energy intensive products / processes</p>	<p>i) Formulation and introduction of mechanisms for the promotion of low energy-intensity products &amp; processes in the industrial and commercial sectors: Energy efficient machines / plants; Energy labelling of equipment</p>	<p><b>Policy Studies</b> Policy formulation and introduction of mechanisms for the promotion of low energy-intensity products &amp; processes in the industrial and commercial sectors:</p>
	<p>II) Lack of systems for waste energy/material recovery and reuse, resulting loss of valuable resource</p>	<p>ii) Design, development and commercialization of waste heat recovery and utilization systems in the industrial and commercial sectors</p>	<p><b>Innovation</b> Initiate development and commercialization of waste heat recovery and utilization systems in the industrial and commercial sectors</p>
		<p>iii) Formulation of regulatory procedures and design guidance tools for the establishment of energy efficient building envelopes (for both existing and new facilities)</p>	<p><b>Policy Studies</b> Development of regulations for EE building envelopes (both existing and new)</p> <p><b>Pure &amp; Applied Research</b> Development of energy performance rating schemes for buildings</p> <p><b>Innovation</b> Exploration of innovative concepts for enhancement of energy performance of buildings</p> <p><b>Indigenous knowledge &amp; Intellectual Property Rights</b> Exploration of EE building concepts used in traditional buildings</p>

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
			<p><b>Testing, standardization &amp; Accreditation</b> Certification and accreditation of EE / green building consultants</p> <p><b>Capacity Building</b> Training programmes on EE building designs</p> <p><b>Popularization</b> Awareness and popularization of EE buildings</p>
<p><b>11) Energy Conservation in the Power Sector</b></p>	<p>i) Limited energy efficiency improvement interventions in power generation facilities</p>	<p>i) Design optimization and introduction of waste-heat recovery and utilization systems for power plants</p>	<p><b>Pure &amp; Applied Research</b> Conduct research on Design optimization and introduction of waste-heat recovery and utilization systems for power plants</p>
<p><b>12) Energy Conservation in the Transport Sector</b></p>	<p>i) Energy efficiency / fuel economy aspect of the transport sectors has not been properly dealt with, resulting over-burden in relation to energy and to development sustenance</p>	<p>i) Formulation and enforcement of fuel economy standards for road vehicles</p>	<p><b>Policy Studies</b> Development of regulations on fuel economy standards for road vehicles</p> <p><b>Pure &amp; Applied Research</b> Development of representative driving cycles covering strategic regions</p> <p><b>Innovation</b> Development of innovative approaches for formulation of driving cycles</p> <p><b>Testing, standardization &amp; Accreditation</b> Development of testing procedures and accreditation of chassis dynamometer testing facilities</p> <p><b>Capacity Building</b> Training programmes on formulation of fuel economy standards</p> <p><b>Popularization</b> Awareness and popularization of fuel efficient vehicles</p>

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
		ii) Development of less energy-intensive transport system: Public transport systems, Bus rapid transit (BRT), Mass Rapid Transit (MRT)	<p><b>Policy Studies</b> Development of transport sector master plan promoting public transport systems</p> <p><b>Pure &amp; Applied Research</b> Impact assessments on public transport modes on fuel economy and other socio-economic aspects</p> <p><b>Innovation</b> Development of innovative approaches in integrating mass /transport systems to present infrastructure</p> <p><b>Information and Communication Technologies</b> Use of ICT for optimum utilization of public/ mass transports</p> <p><b>Capacity Building</b> Training / capacity building programmes on public / mass transport systems</p> <p><b>Popularization</b> Awareness and popularization of public /mass transport modes</p>
	II) Non technical options for energy efficient transport systems are yet to be adopted effectively	i) Development of less energy-intensive transport system: Non-technical options (supply/demand management) and use of ICT	<p><b>Policy Studies</b> Development of policy interventions for promotion of supply/ demand management</p> <p><b>Pure &amp; Applied Research</b> Impact assessments on supply /demand management interventions on fuel economy and other socio-economic aspects</p> <p><b>Innovation</b> Development of innovative approaches for</p>

Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
			<p>supply/ demand management in transport</p> <p><b>Information and Communication Technologies</b> Use of ICT for optimum utilization of public/ mass transports</p> <p><b>Capacity Building</b> Training / capacity building programmes on transport supply/ demand management techniques</p> <p><b>Popularization</b> Promotion of transport supply/demand management interventions</p>
	<p>III) No systems to promote inter-modal transport; and less use of non-motorized transport (NMT) modes, , which increased energy intensity in transport</p>	<p>i) Development of less energy-intensive transport system: Inter-modal transport systems</p>	<p><b>Policy Studies</b> Development of policy interventions for promotion of NMT</p> <p><b>Pure &amp; Applied Research</b> Impact assessments on NMT on fuel economy and other socio-economic aspects</p> <p><b>Innovation</b> Introduction of innovative concepts for best integration of NMT in present transport sector</p> <p><b>Capacity Building</b> Training / capacity building programmes on NMT systems</p> <p><b>Popularization</b> Promotion of NMT modes</p>
<p><b>13) Energy Efficient Zones / Communities</b></p>	<p>I) The power of community, in adopting holistic approach where public and private sectors make a collective commitment and work towards to be</p>	<p>i) Development of mechanisms, guidelines and planning tools to establish energy efficient townships /urban communities (e.g. the concept</p>	<p><b>Innovation</b> Develop mechanisms, guidelines and planning tools to establish energy efficient townships</p>



Sub Areas	Issues/Problems	Research and Development Needs	Relevant Interventions
	<p>more efficient in the use of energy and maximize the exploitation of RE resources, for sustainable development has been not explored so far, leading to inefficient systems and processes across the whole community and infrastructure</p>	<p>of liveable cities)</p>	<p>/urban communities</p>
<p><b>14) Smart metering</b></p>	<p>i) End-use sector electricity conservation and management through advance concepts such as smart metering and dynamic pricing is yet to be implemented, thus failing to achieve higher energy efficiencies</p>	<p>i) Formulation and introduction of pricing mechanisms / incentive schemes for demand peak clipping and valley filling, EV charging and discharging, and other DSM initiatives.</p>	<p><b>Pure &amp; Applied Research</b>            Conduct a survey for introduction of pricing mechanisms / incentive schemes for demand peak clipping and valley filling, EV charging and discharging, and other DSM initiatives.</p>

**\*Table 3: Interventions and Key Performance Indicators**

Sub Areas and Issues/ Problems	Interventions/Activity									
	Policy Studies	Pure & Applied Research	Innovation	Information and Communication Technologies	Nanotechnology	Biotechnology	Indigenous knowledge & Intellectual Property Rights	Testing, standardization & Accreditation	Capacity Building	Popularization
1. Resource Assessments of indigenous energy resources										
<u>Issue:</u> Lack or unavailability of indigenous energy resource maps/inventories, affecting energy planning at national and local levels										
<u>Activity:</u> i) Development of small hydro, wind, solar and biomass resource maps, inventories, road maps	Policy interventions for RE Road map with long term targets	Development of RE resource maps, inventory and roadmaps	Development of innovative resource mapping techniques	Integration of ICT for resource measurements and mappings					Capacity building on modelling/simulation	Dissemination of information on RE resource
<b>Time Frame (I, S, M)</b>	—	—	S	—					—	S
<b>KPI</b>	Long term RE Targets established	No. of regions covered in each RE resource (SHP – 4, Wind – 4, Solar – 4, Biomass – all distract)	Resource maps incorporated with optimized measurement and modelling techniques	ICT integrated resource maps					No. of training programmes conducted (05)	No. of project proponents / users access the resource maps
<b>Lead Institute</b>	SEA	SEA	SEA	SEA					SEA	SEA

*\*Please note that this is only a sample page*

