Confederation of Indian Industry
Since 1895

Ministry of New & Renewable Energy
Govt. of India

Human Resource Development Strategies for Indian Renewable Energy Sector

Final Report
October 2010

CONTENTS

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b. Executive Summary

India has witnessed an exponential growth in renewable energy sector achieving a total installed capacity of 17,174 MW (excluding large hydro) as on 30.06.2010 *(Source: MNRE Achievements http://www.mnre.gov.in/).* The Ministry of New and Renewable Energy (MNRE), Government of India which has been pioneering this activity, has plans to facilitate further growth to achieve the vision of 'affordable and reliable clean energy' to every citizen of the country.

The rapid growth in this sector would require an extensive pool of competent manpower (knowledgeable and skilled) to design, install and maintain the RE systems. Against this background the MNRE has proactively initiated a project to estimate the future Human Resource (HR) needs in the Renewable energy sector and evolve suitable HRD strategies for meeting them. CII appreciates MNRE on this excellent initiative and is glad to be involved in this project.

Objective & Deliverables

The objective of this project is to estimate the existing and future job opportunities and evolve HRD strategies in renewable energy sector.

The deliverables of the project includes the following:

a. Analysis of the trends in Renewable Energy Industry.
b. Quantification of existing job opportunities in different functional areas.
c. Estimation of manpower requirements in Renewable Energy sector in short (5 years) and medium term (5-10 years)
d. Map the skill requirements at different functional levels.
e. Develop sector wise HRD strategies.
f. Develop strategies for possible partnership models between industry, institutions and government towards skill development.
g. Develop inputs to integrate renewable energy into the current curricula at ITI and University level.

Methodology & Approach

CII adopted an inclusive mechanism of convening a Steering Committee comprising of all the stakeholders (Industry, Government, Users, Educational institutions, etc.) to steer and guide the project. A stakeholder meeting was convened at the beginning to seek the views of all the stakeholders and develop the overall methodology for executing the project. Two distinct questionnaires (one each for the industry and educational Institutions) were prepared for seeking data and inputs from the stake holders. 110 filled-in questionnaires were received.

To seek further insights, CII met in person 75 members (industry, educational institutions, nodal agencies, government). The existing literature were also surveyed and relevant information was sourced from reliable sources such as UNEP, ILO, REN, etc.,

The data collected through the questionnaire survey, personal meetings and literature survey were presented to MNRE through an interim report, for comments and suggestions.

Findings of the Project

I. **Trends in renewable Energy –** By 2010, the total cumulative Renewable energy capacity installed (excluding large Hydro power) across the globe was 305 GW (*Source - REN21 Renewables Global Status Report 2010*). Of this, the contribution of wind energy was about 159 GW, followed by 60 GW from small hydro and 54 GW from bio-mass based power generation. China leads the table with an installed capacity of 62 GW followed by USA, Germany, Spain, India and Japan. By 2030, the RE sector globally is expected to grow four - fold to reach a capacity of 1120 GW. The biomass sector which is manpower intensive is expected to grow faster and would be the major contributor of the total power generation (about 59 %) followed by Solar PV (31 %) and Wind (10 %) by 2030 (*Source - REN21 Renewables Global Status report 2008 & 2009 update*).

   India has an installed capacity of 17,174 MW (excluding large hydro) as on 30th June 2010, which is about 10.4 % of the total power generation capacity (*Source: http://www.powermin.nic.in/ indian_electricity_scenario/introduction.htm*) . Currently the Wind sector contributes a major portion of this capacity (12,010 MW) followed by the Small Hydro (2,767 MW). MNRE has ambitious plans for growth in all the RE sectors, some of which are highlighted below – Generate 20,000 MW from on-grid solar power by 2022 under the Jawaharlal Nehru National Solar Mission, Increase small hydro power addition from the present level of 300 MW / year to 500 MW / year in the next 3 years (*Source - http://mnre.gov.in/speeches/clean-energy-speech-23062010.pdf*), Generation based incentive to increase wind energy by another 4000 MW in the years 2010 – 12 (end of 11th plan) (*Source - http://mnre.gov.in/press-releases/press-release-17122009.pdf*). The details are further elaborated in Chapter 2.

II. **Existing job opportunities in different sectors and functional areas** - In the year 2008, globally 2.3 million people were employed in the Renewable Energy sector with biomass contributing to nearly 50 % followed by solar thermal (about 25 %) and wind energy. The RE sector in India is currently (2010) estimated to employ 3,50,000 people, which includes both direct and indirect employment. The employment is currently distributed

across all the major RE sectors like bio-gas, solar PV (off-grid), solar thermal (both off-grid and on-grid), wind, bio-mass (on-grid) and bio-mass gasifier. The functional areas of these existing jobs include – manufacturing, fabrication, installation, operations & maintenance, project development and marketing. This is based on the detailed questionnaire survey, discussions and the data collected from various experts from the field. The details are elaborated in Chapter 2

III. **Manpower growth in short term (2015) and medium term (2020) –** The global employment in RE is expected to increase nine-fold to reach a figure of 20 million jobs by 2030, with biomass leading the growth at 59 % of total capacity followed by solar PV at 31 % and wind. **The higher growth rate in jobs (9 fold) vis-à-vis the installed capacity (4 fold) is on account of the larger contribution from the biomass sector, which is more man-power intensive than the other sectors** (*Source – Green Jobs – Towards decent work in a sustainable, low carbon world, UNEP / ILO/IOE/ITUC, Sep 2009*).

In the case of India, the employment opportunities would increase many fold by the year 2015 (short term) and also by 2020 (medium term). A 'bottom-up' approach has been adopted to arrive at the employment opportunities. The following table shows estimated employment considering moderate growth in each of the sectors as Scenario 1 and high growth as Scenario 2.

Scenarios	Estimated Current Employment (No.)	Estimated Employment by 2015 (No.)	Estimated Employment by 2020 (No.)
Scenario 1 (Moderate Growth)	3,50,000	5,89,000	10,51,000
Scenario 2 (High Growth)		6,99,000	13,95,000

The employment is balanced and well distributed across all the major RE sectors and the functional areas of employment include – design, installation, fabrication, operations and maintenance, project development and marketing. The functional distribution of the jobs across the individual sectors and the detailed calculations are dealt in Chapter 2.

IV. **Skill requirements and skill gaps –** Various discussions with experts and the questionnaire survey revealed the following with regard to skill requirements and the skill gaps for the Indian RE sector.

a. The skill gaps are sector specific (wind, bio-mass, etc.) as well as generic.

b. The generic skill gaps identified in the RE industry are – **Planning & co-ordination skills in project management, erection, commissioning and grid integration of large scale RE projects, installation and commissioning skills and techno commercial marketing skills.** These skill gaps can be addressed through common workshops and training programs.

c. Several sector specific skill gaps need to be addressed and these need unique interventions. Some of the sector specific skill gaps identified include – **design and fabrication of biomass gasifiers, erection and commissioning of large scale bio-mass plants, feedstock planning and management of bio-mass plants, design and installation of BIPV systems, grid integration of megawatt scale solar PV, trouble shooting of solar PV lantern and home lighting circuitry, design skills to match wind speeds and capacity of turbines, installation of large scale turbines, operation and maintenance & failure analysis of turbine gear boxes, GIS / GPS based planning of hydro resources, assembly and trouble shooting of hydro turbines, etc.** The sector specific gaps are detailed in Chapter 3.

V. **Generic and sector specific HR strategies including possible partnership models between industry, institutions and government for bridging skill gaps –** The sector specific interventions are several in nature and are dealt in greater detail in Chapter 5. Few of the generic HR strategies include the following:

a. **Interventions for attracting talent into RE sector –** Industry associations like CII with support of MNRE to work with universities in increase campus interviews by RE companies, MNRE & Industry to offer stipend to students pursuing post graduation in Renewable energy

b. **Organizing of RE Job fairs by industry associations –** Organizing of RE job fairs can facilitate in bringing the industry, educational institution to a common platform and facilitate in employment by the industry. This model has been quite successful in IT sector.

c. **Publicity campaign to highlight the career opportunities in the RE sector –** The awareness on the challenging career opportunities in RE sector is low amongst the students and other stakeholders. MNRE should create a nationwide publicity campaign through advertisements in both the print and electronic media to generate more awareness. (A very catchy example has been the **'Join Army'** campaign by the Ministry of Defence)

d. **Encourage Industry – Institute partnership –** Industry to partner with universities and work as visiting faculty, take summer interns from colleges. Industry association with support from MNRE to facilitate.

e. **Encourage web-enabled RE education and distance education programs in RE technologies**

f. **Promote innovative applications of RE technologies to create new RE jobs –** New applications such as solar air-conditioning, Building Integrated Photo Voltaic systems (BIPV), in-situ wind turbines in buildings, in-situ power generation by fuel cells can create substantial number of jobs. MNRE should consider initiating a study to explore this opportunity

g. **Develop 1000 accredited RE trainers by 2015 who can impart skill based training –** CII with the support of MNRE can develop the modules and offer the 'Training of Trainer' programs. Sector specific programs can be developed and offered.

h. **Incubate and hand-hold 500 green entrepreneurs involved in manufacturing of RE products, technologies by 2015, to create new jobs –** This would involve publicity on green entrepreneurship, allocating funds for incubation and financing of RE entrepreneurs and setting up of RE parks, similar to SEZs.

i. **Establish a centre of excellence in Renewable energy –** To be set up through Public Private Partnership (PPP) mode. The centre would offer training, advisory, incubation and policy facilitation services for promoting RE.

VI. **Inputs for strengthening Universities and ITI's on renewable energy curricula, improving infrastructure etc–** Only 52 out of a total of about 1346 technical institutions *(See Annexure 4, Source: AICTE Annual Report 2006-07)* in India offer postgraduate courses in Energy Management with electives on RE. Out of the 910 students who graduate in Energy Management with RE electives, majority of them take up jobs in IT and manufacturing sector as the salaries are higher. Also the infrastructure at the Universities is not adequate and the industry finds it difficult to employ the graduates passing out of the Universities as well the ITI's, as they do not have the requisite skills. Hence there is a need to fine-tune and improve the curricula, improve the infrastructure at the Universities so that they meet the future HR requirements of the industry. Some of the suggestions made are as under:

a. **Committee comprising of AICTE, MNRE and industry to be formed -** To develop the curricula based on the latest RE technologies, applications and manufacturing practices.

b. **Promote collaboration between Indian universities and world class universities abroad for adopting best practices in imparting RE skills –** MNRE should facilitate and encourage Indian Universities to partner with global bests in RE to enhance knowledge and skill base. Wuppertal Institute for climate, environment and energy, Germany, School of Photovoltaic and Renewable Energy, University of New South Wales, Australia and Centre for Energy Efficiency and Renewable Energy (CEERE), University of Massachusets, USA are some of the overseas universities suggested.

c. **One time Infrastructure fund for Universities offering RE courses –** MNRE in association with UGC / AICTE should offer a one-time infrastructure fund so that universities offering RE courses can upgrade their infrastructure (labs, working models and library)

d. **Vocational training for ITI / Polytechnic students –** ITI's and Polytechnics in consultation with Industry should develop focused 3 months / 6 months vocational courses, which make the students employable by the industry.

e. **Develop fulltime PG courses on RE at PG level in select universities** – MNRE in consultation with AICTE and industry to explore developing a full time PG course on RE systems with specialization on Wind, Bio-mass and Solar.

f. **Enhance the number of seats available at the PG courses in universities for RE**

The details are further elaborated at Chapter 5.

To sum-up, the RE sector has a major role to play in ensuring the energy and ecological security of the country. The Ministry of New and Renewable Energy, Government of India has plans for increasing the capacity of power generation through Renewable energy sources and has been playing a pioneering role in creating a conducive atmosphere and catalysing growth in the sector. The study reveals that right interventions in terms of HR strategies with the involvement of all the stake holders can go a long way in achieving the national targets.

Chapter 1

Introduction

India has witnessed an exponential growth in renewable energy sector during the last few years. Renewable energy generation in India has reached a total installed capacity of 17,174 MW as on 30.06.2010 (excluding large hydro).

The share of different sub-sectors is given below:

1.1 Renewable Energy – Installed capacity in India as on 30.06.2010

Table 1.1.A: Grid-interactive renewable power

Sl No.	Renewable Energy Source	Installed Capacity (MW)	India's position in World
1	Wind	12,010	Fifth
2	Small Hydro (up to 25 MW)	2,767	Tenth
3	Solar PV	12	Second
4	Biomass Power (Agro residues)	901	Fourth
5	Cogeneration-bagasse	1412	
4	Waste to Energy	72	
	Total	17,174	

(Source: MNRE Achievements as on 30.06.2010 - http://www.mnre.gov.in/)

Table 1.1.B: Off-Grid/Distributed Renewable Power (including Captive/CHP Plants)

Sl No.	Renewable Energy Source	Installed Capacity (MW/MWeq)
1	Biomass Power / Cogen.(non-bagasse)	238
2	Biomass Gasifier	125
3	Waste- to- Energy	53
4	Solar PV Power Plants	3
5	Aero-Generators/Hybrid Systems	1
	Total	420

(Source: MNRE Achievements as on 30.06.2010 - http://www.mnre.gov.in/)

India is a leader in wind, biomass and solar PV sectors and ranks among the top ten countries of the world in renewable energy. India is the only country in the world which has a dedicated Ministry for Renewable Energy (Ministry of New & Renewable Energy, GoI), proactively creating an enabling environment for the sector to grow by rapidly bringing in innovative policy initiatives. The country is well poised to facilitate and advance the growth of renewable energy and enable become one of the world leaders in all sectors of renewable energy in the coming years.

While the growth in renewable energy is a step in the right direction, it poses few challenges and at the same time provides a plethora of opportunities. One of the major challenges is to meet the growing need for skilled manpower, both in terms of quality and quantity, in the renewable energy sector.

Some of the key issues related to manpower are the following:

- **Availability of adequate skilled manpower**

  The sector is facing challenges in sourcing skilled manpower in many functional areas like manufacturing, production, installation, operation & maintenance, marketing and research & development. As the sector is relatively new and fast growing, there is a shortage of experienced / skilled manpower. It is also important to note that the renewable energy sector is more manpower-intensive than the conventional energy sector.

- **Attracting talent**

  Though the sector has several qualified, competent and skilled manpower, it is not able to attract further talent, as the salaries / compensation packages offered by the RE industry are not comparable to those offered by other industries. There is also a general lack of awareness amongst the student community on the challenging career and entrepreneurial opportunities that exist in this sector.

- **Training and capacity building**

  The installation, operation and maintenance of Renewable energy systems need specific skills and knowledge. To impart this skill and knowledge to those entering the sector as well as continuously upgrading them, there is a need for training and capacity building. Currently there is a shortage of RE trainers, who can offer this service to the industry. Also, there is a need to setup institutional mechanisms to offer intensive and comprehensive training in all aspects of renewable energy.

- **Renewable energy curricula in the Universities**

  Though 52 universities in India are offering courses in renewable energy at the post graduation levels, the curriculum and the methodology adopted in teaching needs to be strengthened in order to upgrade the manpower skills, to meet the expectations of the industry.

There is a need to address the demand of skilled & trained manpower in RE sector which would facilitate rapid adoption and advancement of renewable energy in the country. Realizing the importance, Ministry of New and Renewable Energy (MNRE), Government of India, assigned

Confederation of Indian Industry (CII) the task of estimating the human resource needs in renewable energy sector and evolving suitable Human Resource Development (HRD) strategies.

1.2 Objective

The objective of the project is to estimate the existing and future job opportunities and evolve HRD strategies in renewable energy sector.

1.3 Deliverables

a. Analysis of the trends in Renewable Energy Industry.
b. Quantification of existing job opportunities in different functional areas.
c. Estimation of manpower requirements in Renewable Energy sector in short (5 years) and medium term (5-10 years)
d. Map the skill requirements at different functional levels.
e. Develop sector wise HRD strategies.
f. Develop strategies for possible partnership models between industry, institutions and government towards skill development.
g. Develop inputs to integrate renewable energy into the current curricula at ITI and University level.

1.4 Approach and Methodology

a. **Steering committee**- The project was executed under the guidance of the standing Renewable Energy Council of CII - Godrej GBC, which comprises of eminent members from the industry, academia and government. CII has adopted an inclusive mechanism by seeking the views, perceptions and suggestions of the nodal agencies, industry (users and manufacturers) and academia in conducting this study.

b. **Stakeholder meeting** - A stakeholder meeting was organised in February 2010 at New Delhi where in the project action plan and methodology was finalized in consultation with all the stakeholders.

c. **Questionnaire survey** –Data collection questionnaires were prepared by CII in consultation with stakeholders. Distinct questionnaires were prepared for the industry and institutions. The objective of this exercise was to reach out to all the stakeholders across the country and obtain feedback from them. The sample questionnaires used for the survey are enclosed as Annexure. Around 250 questionnaires were circulated and feedback was obtained from 100 organisations. The objective of the questionnaire survey was to seek the inputs on – Current employment, future growth, potential employment opportunities, skill gaps and the actions required for bridging the skill gaps.

d. **Inputs from stakeholders (industry, academia, government)** – Subsequent to the questionnaire survey, to seek further insights, more than 75 organizations were met on 'one-to-one' basis. This involved visits to various industries in RE sector, premier educational institutions and industry associations.

e. **Data collection & analysis** (Secondary source) - Extensive data collection was also done through secondary sources as part of the study. This involved information collection from authentic reports published by United Nations Environment Programme (UNEP), International Labour Organisation (ILO), Renewable Energy Policy Network for the 21st Century (REN 21), Sustainable Energy Finance Initiative (SEFI) and GREEN PEACE to name a few. The data collected and the opinions, views & perceptions of the stakeholders have been taken into account are presented in this report.

f. **Evolve action plan & strategies** – Based on the findings of this study, few strategies are recommended for implementation (Chapter 5)

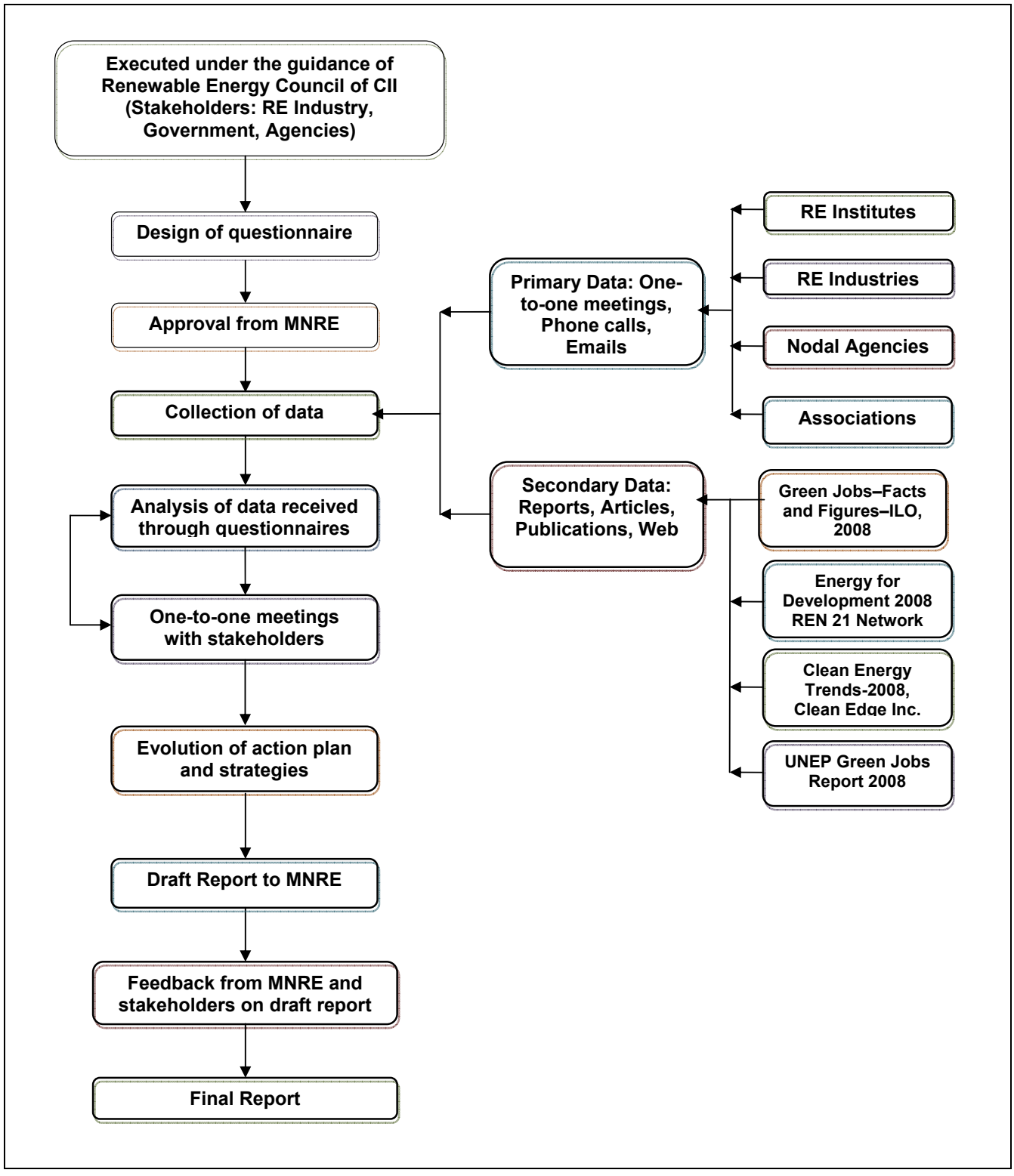

Figure 1.1: Process Chart for the Study

Chapter 2

Analysis of Current Trends in Renewable Energy Sector – Impacts on Employment Opportunities

2.1 Global Scenario

The total installed renewable power capacity across the globe by 2010 is 305 GW (Source: *REN21 Renewables Global Status Report 2010),* excluding large hydropower. Renewable energy comprises about a quarter of global power-generating capacity (estimated at 4,800 GW in 2009). The share of various sources of renewable energy is depicted in Figure-2.1. The total installed capacity is expected to grow to 1120 GW by the year 2030, a four-fold increase vis-à-vis the capacity in 2010.

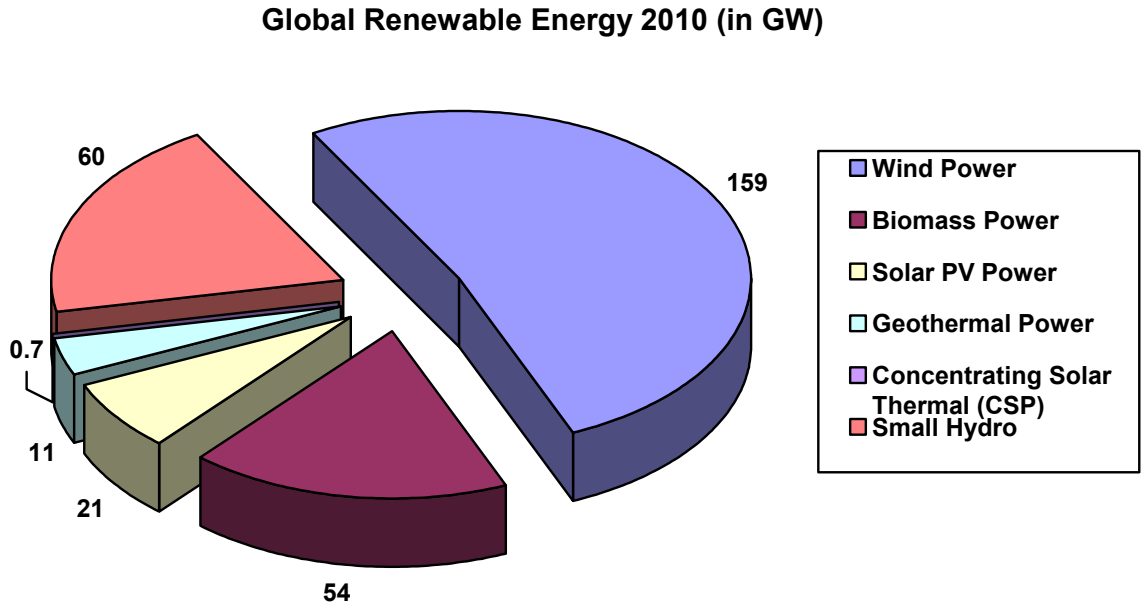

Figure 2.1: Global Installed Capacity of Renewable Energy
(Source: REN21 Renewables Global Status Report 2010)

Amongst the various sources of renewables, wind power and biomass contributed to a major share (70 %) of the total capacity of 305 GW.

The installed capacity of renewable energy in top 6 countries by 2010 is shown in Table-2.1

Table 2.1: Renewable Energy Installed Capacity in Top 6 Countries

Sl No.	Country	Installed Capacity in GW
1	China	62
2	United States	52
3	Germany	42
4	Spain	25
5	India	17
6	Japan	9
	Total	**207**

(Source: REN21 Renewables Global Status Report 2010)

2.2 Global Employment in Renewable Energy

Given the phenomenal growth of renewable energy worldwide, jobs in renewable energy have rapidly increased during the recent years and the sector will witness even higher growth in future.

As on today it is estimated that there are more than 2.3 million people employed globally in the renewable energy sector *(Source: Green Jobs – Towards Work in a Sustainable, Low-Carbon World, UNEP/ILO/ITUC).*

The break-up of employment in select countries is shown below:

Table 2.2: Global employment in renewable energy – Select countries

Sl No.	Renewable energy source	Total employment globally	Selected Countries	
1	Wind	300,000	Germany	82,100
			United States	36,800
			Spain	35,000
			China	22,200
			Denmark	21,000
			India	10,000
2	Solar PV	170,000 *	China	55,000
			Germany	35,000
			Spain	26,449
			United States	15,700
3	Solar Thermal	624,000 - plus	China	600,000
			Germany	13,300
			Spain	9,142
			United States	1,900

4	Biomass	1,174,000	Brazil	500,000
			United States	312,200
			China	266,000
			Germany	95,400
			Spain	10,349
5	Small Hydropower	39,000 – plus	Europe	20,000
			United States	19,000
6	Geothermal	25,000	United States	21,000
			Germany	4,200
	Total	**2,332,000**		

(Source: Green Jobs - Towards Decent Work in a Sustainable, Low-Carbon World, UNEP/ ILO/ IOE/ ITUC)

** Under the assumption that Japan's PV industry employs roughly as many people as Germany's PV industry.*

Figure-2.2 compares the renewable energy jobs in 2006 with those projected for 2030.

It is estimated that Biomass, Solar PV and Wind alone would employ 20 million people by the year 2030, which is a 10-fold increase as compared to the employment in 2006.

The share of employment in biomass would be the largest (59%), followed by solar PV (31%) and wind (10%).

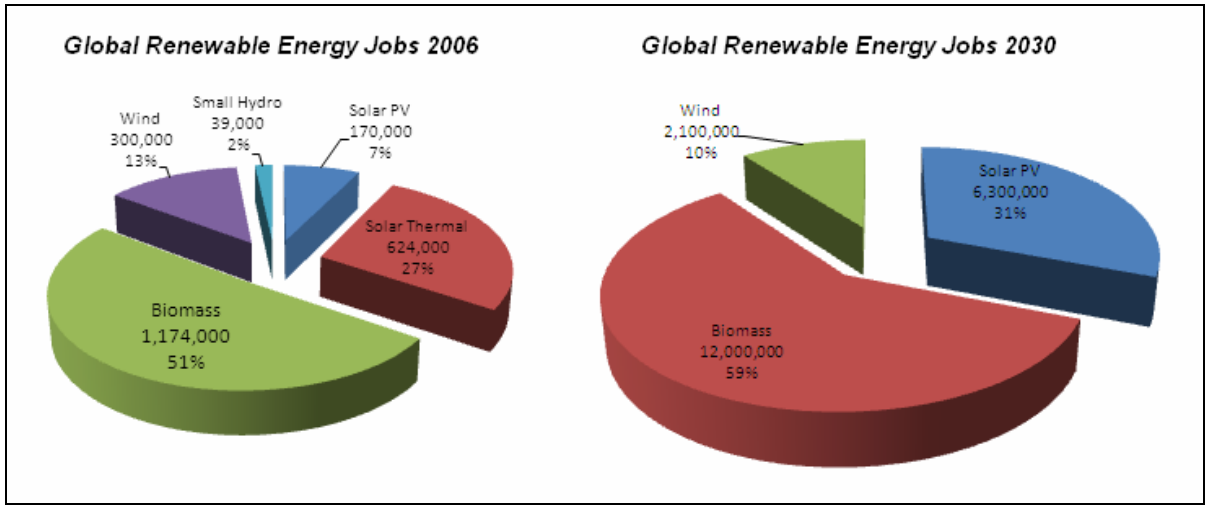

Figure 2.2: Global Renewable Energy Jobs 2006-2030

(Source: Green Jobs – Towards Work in a Sustainable, Low-Carbon World, UNEP/ILO/ITUC)

The following table captures the phenomenal growth that this sector would witness by 2030.

Table 2.3: Global Growth of Renewable Energy 2010 - 2030

Sl No.	Indicators	2010	2030
1	Investment (Billion $)	150	600
2	Installed Capacity (GW)	305	1120
3	Employment (Million)	2.3	20

(Source: Green Jobs – Towards Work in a Sustainable, Low-Carbon World, UNEP/ILO/ITUC, September 2010)

2.3 Indian Scenario

Trends and Growth in Renewable Energy Sector in India

India has enormous potential to harness the much-needed energy from renewable sources and is considered as one of the ideal investment destinations.

The total installed capacity of renewable power in India was about 17,174 MW as on 30.06.2010 (Figure 2.4). This constitutes about 10.4 % of the total power generation capacity. *(Source: http://www.powermin.nic.in/ indian_electricity_scenario/introduction.htm)*

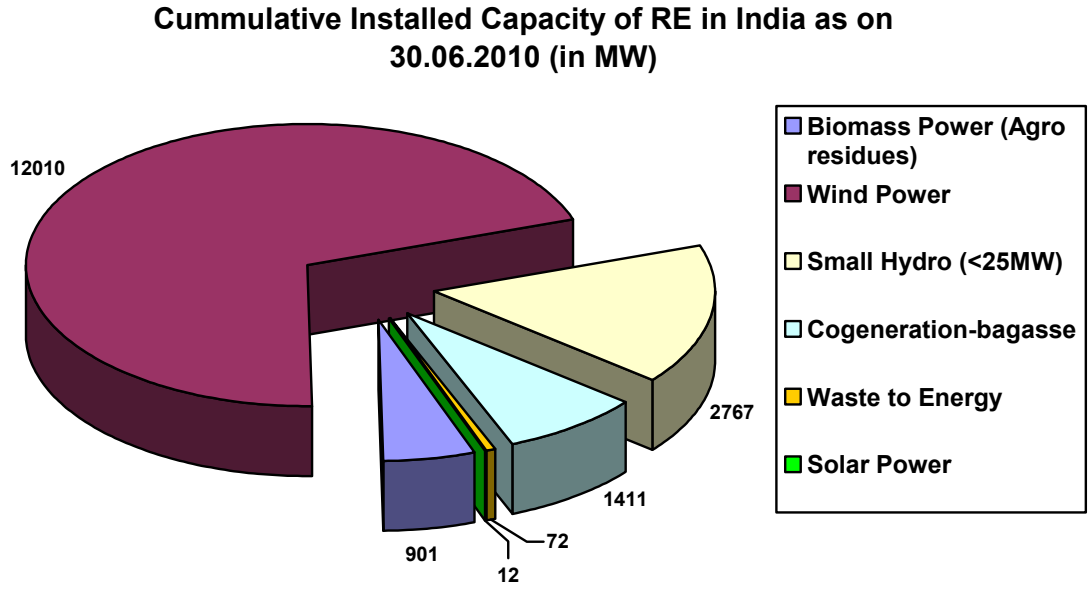

Figure 2.3: Cumulative Installed Capacity of Renewable Energy in India
(Source: MNRE Achievements as on 30.06.2010 - http://www.mnre.gov.in/)

2.4 Estimation of Existing Employment in Indian RE Sector

A study was carried out to estimate the existing employment in various sectors of renewable energy in India. This included site visits, feedback through surveys and one-to-one discussions with various stakeholders.

2.4.1 Wind Energy

Based on extensive interactions with major players, the approximate employment in wind energy sector was estimated as shown below.

Table 2.4: Estimated Current Employment in Wind Energy

Current addition or mfg / year (MW)	Cumulative capacity till Oct 2009 (MW)	Direct Employment	Employment in O & M	Indirect Employment	Total Employment
1,400**	**10,900 ***	**10,500**	**3,500**	**28,000**	**42,000 ****

* *Source: MNRE Annual Report 2009 - http://www.mnre.gov.in/*

** From secondary sources and industry survey. For details, refer Annexure 1

The approximate distribution of manpower across different functional areas of operation is provided below**:**

Table 2.5: Estimated employment distribution across various functional areas (approximate)

Type of Employment	Employment	Functional Area of operation	Percentage of people employed (%)*
Direct	14,000	Manufacturing	20
		O & M	25
		Project Development	30
		Marketing	25
Indirect	28,000	-	-
Total	**42,000**	**-**	**100**

* For details, refer Annexure 1

It can be seen from the table above that the major functional areas of employment in wind energy sub-sector are **project development, operations & maintenance and marketing**. Hence, capacity building and skill development efforts need to be prioritized in these areas.

Future projections

The Generation Based Incentive scheme (GBI) of MNRE is expected to boost the growth of wind energy sector. The estimation of future potential employment in wind energy sector is carried out under three scenarios:

Scenario 1: Growth rate 6 % (Moderate)
Scenario 2: Growth rate 10% (Medium)
Scenario 3: Growth rate 15% (High)

The future manpower potential under the above scenarios is shown in Table 2.6

Table 2.6: Future Projections for Employment in Wind Energy Sub-sector

Year	Scenario 1 (6% growth) Moderate			Scenario 2 (10% growth) - Medium			Scenario 3 (15% growth) - High		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Existing	Direct: 14,000 ; Indirect : 28,000 ; Total : 42,000								
2015	16,000	28,000	44,000	17,500	29,000	46,500	28,000	52,000	80,000
2020	18,000	28,000	46,000	28,000	47,000	75,000	55,000	1,05,000	1,60,000

It is estimated that, at a moderate growth of 10% the wind sector would employ about 75,000 people by the year 2020 and going by the existing growth rate of 15% over the last two to three years, the sector would offer livelihood to 1,60,000 people by the year 2020.

2.4.2 Solar PV On-grid

The solar PV on-grid sub-sector is at a nascent stage in India. With the Jawaharlal Nehru National Solar Mission (JNNSM) scheme of the Government of India, the installed capacity is estimated to reach 20 GW by the year 2022. This would create enormous employment opportunities in the country.

To achieve the JNNSM target, at least 200 MW of on-grid solar power needs to be installed in the next one year and the manufacturing capacities have to be ramped up progressively at the rate of 50 % every year, till the target of 20 GW is achieved.

Table 2.7: Estimated Current Employment in Solar PV On-grid

Current addition or manufacturing / year (MW)	Direct Employment - Manufacturing	Direct Employment – O & M	Total Employment
200	**4,000**	**Very low**	**4,000 ***

* For details, refer Annexure 2

Table 2.8: Future projection for Solar PV on-grid employment

JNNSM Mission Targets (MW)	Year	Estimated Employment		
		Manufacturing	O & M	Total
1000	**2013**	9,000	4,000	13,000
10,000	**2017**	25,000	14,000	39,000
20,000	**2022**	93,000	59,000	1,52,000

Considering the JNNSM targets, it is estimated that the Solar PV on-grid sector would employ 39,000 people by the year 2017 and 1,52,000 by the year 2022. It augurs well for the country in enhancing the installed solar energy capabilities and at the same time meet the social objective of creating new job opportunities.

2.4.3 Solar PV Off-grid

The country currently manufactures around 800 MW of solar panels, of which 90 % is catering to the export market. This sector today is estimated to have an employment of 72,000, including direct and indirect employment. Direct employment are those involved in **manufacturing and assembly** and the indirect employment comprises of **dealers, marketing staff of dealers, lantern manufacturers, dealers and manufacturers of solar home lighting kits, battery manufacturers, lamp manufacturers, etc.,**

Table 2.9: Estimated Current Employment in Solar PV off-grid

Current addition or manufacturing / year (MW)	Direct Employment	Indirect Employment	Total Employment
800	**24,000**	**48,000**	**72,000 ***

* For details of estimation, refer Annexure 3

The export market and the indigenous off-grid applications in the country would continue to grow and it is expected to grow at about 10% for the next ten years. The sector would employ about 1,40,000 people by the year 2017 and 2,25,000 by the year 2022.

Table 2.10: Future Projections for Employment in Solar PV off-grid Sub-sector

Year	Estimated Employment		
	Direct	Indirect	Total
2010	24,000	48,000	72,000
2017	47,000	93,000	1,40,000
2022	75,000	1,50,000	2,25,000

2.4.4 Solar Thermal – Off-grid

The annual capacity addition of solar thermal systems in the country during 2009-10 is 0.22 million sq.m *(Source: MNRE Annual Report 2009 - http://www.mnre.gov.in*). Based on the feedback obtained from small and large players in this sector, current employment is estimated to be 41,000, details of which are shown in Table 2.11.

Table 2.11: Estimated Current Employment in Solar Thermal Sub-sector

Cumulative capacity till Oct 2009 (Sq.m)	Direct Employment	Indirect Employment	Total Employment *
3.12 million	**3,000**	**38,000**	**41,000**

* For details, refer Annexure 4

As per the JNNSM target, India would install 15 million sq.m by the year 2017 and 20 million sq.m by the year 2020. To meet these targets, the sector is expected to grow at an annual rate of 17 % till 2022. The employment in the sector is also expected to grow at the same rate. The projected employment for meeting these targets is shown in Table 2.12.

Table 2.12: Future Projections for Employment in Solar Thermal Sub-sector

JNNSM Mission Targets (Million Sq.m)	Year	Estimated Employment		
		Direct	Indirect	Total
15	**2017**	9,000	1,14,000	1,23,000
20	**2022**	20,000	2,50,000	2,70,000

2.4.5 Biomass On-grid

Biomass sector is man-power intensive and employs a large population of semi-skilled and un-skilled labour for fuel collection, loading & unloading and fuel processing.

Table 2.13: Estimated current employment (2009) in Biomass On-grid

Cumulative capacity till Oct 2009 (MW)	Direct Employment (Skilled)	Direct Employment (Unskilled)	Indirect Employment	Total Employment *
820	**5,000**	**7,000**	**23,000**	**35,000**

* For details, refer Annexure 5

For estimating the future employment growth the following scenarios are considered:

Scenario 1: The sector grows at the rate of 5 % per annum (Moderate)

Scenario 2: The sector grows at the rate of 10% (High)

Table 2.14: Future Projections for Employment in Biomass on-grid Sub-sector

Year	Scenario 1 (5 % growth) - Moderate			Scenario 2 (10 % growth) - High		
	Direct	Indirect	Total	Direct	Indirect	Total
2015	16,000	31,000	**47,000**	21,500	41,000	**62,500**
2020	20,000	40,000	**60,000**	34,000	66,000	**1,00,000**

At 10 % growth rate, the sector would have about 62,500 people by 2015 and 1,00,000 people by 2020 vis-à-vis 35,000 of current employment. This sector has a potential to offer livelihood to a large section of the rural population.

2.4.6 Biomass Gasifier

Biomass gasifiers are predominantly de-centralized energy devices, mostly in KW size and are ideally suited for community and remote village electrification**.** This sector provides employment to the rural population in the areas of fuel collection, handling and operations. The individual capacities of gasifiers can vary over a wide range, starting from 1 KW to 50 KW. For estimating the current employment, typical size of each installation is considered as 20 kW. Table 2.15 shows details of current employment in this sector.

Table 2.15: Estimated Current Employment in Biomass Gasifiers Sub-Sector

Current addition or manufacturing / year as of 2009 (KW)	Cumulative capacity till Oct 2009 (KW)	Employment in O & M	Employment in Manufacturing	Total Employment
2,910	**1,08,000**	**21,700**	**300**	**22,000**

* For details, refer Annexure 6

The future growth in employment is estimated for the following scenarios:

Scenario 1 : Assumes a growth rate of 5 % per annum (Moderate)

Scenario 2 : Assumes a growth rate of 10 % per annum (High)

Table 2.16: Future Projections for Employment in Biomass Gasifier Sub-sector

Year	Scenario 1 (5 % growth) - Moderate			Scenario 2 (10 % growth) - High		
	Employment in O & M	Employment in Manufacturing	Total	Employment in O & M	Employment in Manufacturing	Total
2015	29,600	400	**30,000**	38,500	500	**39,000**
2020	37,500	500	**38,000**	62,000	1,000	**63,000**

2.4.7 Biogas

Biogas sub-sector predominantly comprises of family size biogas plants. Currently about 41,20,000 units are installed in the country. Majority of people employed in this sub-sector are semi-skilled and unskilled. Since the family size biogas plants are invariably operated by occupants, jobs in operations is not considered while estimating the current and the future employment. This sector would however have a large part of the employment in servicing the installed biogas plants. Typical nature of such employment would include plumbing, burner service and maintenance.

Table 2.17: Estimated Employment in Biogas

Cumulative capacity till Oct 2009 (No.)	Total Employment *
4,120,000	**85,000**

* For details, refer Annexure 7

The future growth in employment is estimated for the following scenarios:

Scenario 1: Assumes a growth rate of 15 % per annum in capacity (Moderate)

Scenario 2: Assumes a growth rate of 20 % per annum in capacity (High)

Table 2.18: Future Projections for Employment in Biogas sector

Year	Scenario 1 Moderate	Scenario 2 High
2015	1,50,000	1,96,000
2020	2,40,000	3,95,000

2.4.8 Small Hydro

The country has a total installed capacity of 2500 MW as on Dec 2009 in the small hydro sub-sector. The survey covered key players in small hydro sub-sector and collected their feedback on employment in the sub-sector. It is estimated the sector current employs about 12,500 people.

Table 2.19: Employment in Small Hydro

Cumulative capacity till Oct 2009 (MW)	Total Employment *
2,500	**12,500**

* Refer Annexure 8 for details

The projected future growth is calculated for the following scenarios:

Scenario 1: Assumes a growth rate of 4 % per annum in capacity (Moderate)

Scenario 2: Assumes a growth rate of 10 % per annum in capacity (High)

Table 2.20: Future Projection for Small Hydro

Year	Scenario 1 Moderate	Scenario 2 High
2015	16,000	20,000
2020	20,000	30,000

2.4.9 Aero-Generators/Hybrid Systems

This sub-sector is still under development and the number of installations are few in number.

The following table shows the employment in this sub-sector based on the feedback obtained from manufacturers and installers.

Table 2.21: Employment in Aero-Generators/Hybrid Systems

Cumulative capacity till Oct 2009 (KW)	Total Employment *
890	**530**

* Refer Annexure 9

2.4.10 Wind-mill Pumps

The number of wind-mill pumps currently installed in the country is 1347 as per MNRE estimate. Based on the interactions with few stakeholders, the total employment in this sub-sector is estimated to be 270.

Table 2.22: Employment in Wind-mill Pumps

Cumulative capacity till Oct 2009 (Units)	Total Employment *
1,347	**270**

* Refer Annexure 9

In addition to the above, there exist a few more technologies like Geothermal, Hydrogen Energy, Solar Thermal and Bio-methanation to name a few, which although have enormous growth potential, are yet to attain a significant market size at present. Hence their impact on the current employment as on date is not significant and hence not considered in this report. CII feels that separate in-depth sector-specific studies are needed to assess the impacts of these sectors on the current and future employment.

2.5 Summary

Based on the above analysis, it is seen that all sectors of renewable energy would witness significant growth. The comparison between moderate growth and best growth scenarios, for the years 2015 and 2020 are shown in Table 2.23.

Table 2.23: Estimated current and future employment of RE sector in India

Sector	Estimated Current Employment	Projected Growth %		Estimated Projected Employment (in No.)			
				2015		2020	
		Moderate	High	Scenario I (Moderate)	Scenario II (High)	Scenario I (Moderate)	Scenario II (High)
Wind	42,000	6	15	44,000	80,000	46,000	160,000
Solar PV On-Grid	40,000	50		39,000*		152,000**	
Solar PV Off-Grid	72,000	50		140,000*		225,000**	
Solar Thermal	41,000	17		123,000*		270,000**	
Biomass On-Grid	35,000	5	10	47,000	62,000	60,000	100,000
Biomass Gasifier	22,500	5	10	30,000	39,000	38,000	63,000
Biogas	85,000	15	20	150,000	196,000	240,000	395,000
Small Hydro	12,500	4	10	16,000	20,000	20,000	30,000
Total	**350,000**			**589,000**	**699,000**	**10,51,000**	**13,95,000**

* Employment for 2017 estimated based on JNNSM targets

** Employment for 2022 estimated based on JNNSM targets

Chapter 3
Skill Gaps in RE Sector

Skill requirements for renewable energy technologies are unique in nature and vary widely across different sub-sectors.

Certain skill requirements are common across all sectors of RE, for example – mechanical maintenance, electrical skills and installation while a few other skills are unique to specific sectors.

Certain skills are sector specific; for example, wind resource assessment, techno-commercial marketing, installation of BIPV systems, boiler and turbine operation & maintenance of biomass power plants, design & operation of biogas plants are highly specific.

This skill mapping survey carried out as part of this report covered the following sub-sectors of RE.

- Wind
- Solar PV
- Solar Thermal
- Small Hydro
- Biomass / Biogas

A detailed questionnaire was designed in consultation with MNRE and circulated to stakeholders of various RE sectors. Questionnaires were sent to 200 stakeholders and 110 companies responded. Select stakeholders were subsequently met in person to seek their perceptions and views. CII has interacted with more than 75 companies & institutions across different sub-sectors in renewable energy and has collected their feedback on skill gaps specific to each sub-sector. The views and perception of the industry are presented below:

Table 3.1: Function-wise Skill Gaps in Biomass, Bio Diesel & Biogas sector

Sub-sector	Functional Area	Skill Gaps
Biomass / Bio-diesel / Biogas		
Biomass / Bio-diesel / Biogas	R&D	❖ Deeper knowledge on oil bearing trees like Jatropha in the areas of seed quality, yield and extraction. ❖ Specialized knowledge on bio-diesel - agronomy, botany, crops, soil and climate research. ❖ Skills and experience in pest & disease management
	Project Development & Consultancy	❖ Project management skills - planning & co-ordination
	Manufacturing	❖ Design & fabrication skills in biomass gasifiers

		❖ Hot gas conditioning systems in biomass gasifiers ❖ Standard design and processes in designing biogas plants
	Construction & Installation	❖ Erection & commissioning of large scale, on-grid biomass power projects.
	Operation & Maintenance	❖ Exposure in handling biomass-based combustion systems ❖ Maintenance and repair of fuel-handling systems ❖ Feed stock planning and logistics in biomass collection
	Marketing	❖ Developing and mentoring village-level franchisee networks. ❖ Techno-commercial marketing skills ❖ Vendor development

Table 3.2: Function-wise Skill Gaps in Solar PV & Solar Thermal systems

Solar (PV & Thermal)		
Solar	R&D	❖ Knowledge and exposure in advanced areas like wafer technology, semi conductor technology. ❖ Design skills in installing BIPV in buildings
	Project Development &Consultancy	❖ Lack of awareness & experience in handling concentrated solar collectors (CSP).
	Manufacturing	❖ Low skills in module assembly ❖ System integration in solar PV
	Construction & Installation	❖ Installation and commissioning of solar thermal systems (SWH). ❖ Third-party installers are not skilled in erection ❖ Grid integration of mega watt scale solar PV power projects
	Operation & Maintenance	❖ Shortage of skills in trouble shooting of circuitry of solar PV lanterns and home lighting systems
	Marketing	❖ After sales service, customer care ❖ Techno-commercial analysis of mega projects in on-grid solar PV

Table 3.3: Function-wise Skill Gaps in Wind based RE systems

Wind		
Wind	R&D	❖ Off-shore wind technology ❖ Accurate wind resource assessment ❖ Skills in optimization of blade angles for maximizing energy output ❖ Better electrical energy storage batteries for small scale wind mills ❖ Development of high-strength fatigue resistant materials for wind turbines ❖ Design improvements in step-up gear boxes

	Project Development &Consultancy	❖ Design techniques to match wind resources and rating of the installations
	Construction & Installation	❖ Installation of high capacity wind turbines
	Operation & Maintenance	❖ Failure analysis of gearboxes of wind turbines
	Marketing	❖ Techno-commercial marketing of wind projects in energy intensive industries
	Other issues	❖ Difficult to retain trained and knowledgeable manpower

Table 3.4: Function-wise Skill Gaps in Small Hydro based RE systems

Small Hydro		
Small Hydro	R&D	❖ Feasibility and assessment potential of small hydro projects. ❖ Real time digital simulation tools
	Project Development & Consultancy	❖ Surveys, investigations and hydrological studies ❖ Design and implementation of run-of-the-river projects ❖ GIS / GPS based planning of hydro resources
	Construction & Installation	❖ Erection and installation of small hydro turbines ❖ Performance testing of small hydro projects
	Operation & Maintenance	❖ Assembly and troubleshooting of small hydro turbines
	Other issues	❖ Lack of soft skills like reporting, data collection at technician level

It is observed that few skills and skill gaps would cut across all sub-sectors:

- Planning and co-ordination skills in project management
- Erection, commissioning and grid integration of large scale projects
- Techno-commercial marketing skills
- Installation & commissioning skills
- After-sales service and customer care.

Some of the key inferences emanating from the skill gaps study are the following.

- Some of the generic gaps that are common across all sectors can be addressed through workshops and training programs.
- There are areas in each sector where highly specialized skills are required. In such areas, sector specific trainers need to be developed to fill the gaps. Industry experts should be encouraged to offer services as visiting faculties in universities.
- Exposure at the ITI and Universities can help in building awareness, but highly specific skills need to be imparted in the industry.
- The country needs skilled and knowledgeable trainers for which modules and programs should be developed on 'Training of the Trainers'. There is a requirement to have an institutional model to address this requirement.
- The syllabus at the ITI and Universities need to be revisited to strengthen and build awareness on the RE sector.
- Setup R&D laboratories in the country to encourage research. Research should also be encouraged in established universities.

Skill development is of paramount importance in job creation, improving productivity and standards of living. Hence it calls for concerted efforts by MNRE, industry and institutions to address the gaps identified.

Chapter 4
RE Curricula in Educational Institutions

It is estimated that, there would be 3-4 fold increase in renewable energy installations in the next 10 years, which in turn will create number of job opportunities in this sector. Providing quality renewable energy education at various levels is of paramount national importance.

4.1 Details of the institutions offering RE courses

The AICTE database shows that, presently there are approximately 1346 engineering colleges in the country. Of these, only 52 engineering colleges offer courses on Energy Management in PG level, in which renewable energy is one of the major electives. Annexure-10 shows the state wise details of the colleges and Annexure-11 shows the details of the colleges, offering PG courses. Table 4.1 indicates the details of the engineering colleges offering RE courses.

Table 4.1: Engineering colleges offering RE Courses at the PG level

Total Number of Engineering Colleges in India	Colleges offering Energy Management Course in PG level (RE as major elective)	% of colleges
1346	52	3.8

(Source: AICTE website: http://www.aicte-india.org*/)*

CII interacted with several educational institutions and students to understand the current situation with regard to responses of the students on RE courses that are offered. Following are the key observations:

- It is estimated that every year more than 40,000 students pursue their Post Graduation Courses under various streams. The estimated number of students opting for Energy Management courses is only 910, which forms 2.25% of the PG students.
- Furthermore, only 60%-80% of the PG seats offered in Energy Management get filled
- Out of these 910 students; more than 60% choose IT sector jobs as their career and majority of the rest are employed by industries / consultancy firms involved in Energy Management. Only very few students opts for renewable energy jobs
- This shows that the actual number of students opting for renewable energy jobs is very less compared to the needs of the sector.

Table 4.2: Percentage of students pursing PG course in Energy Management

Total Number of Students pursuing Post Graduation / year	Students Opting Energy Management Course in PG level (RE as major elective)	% of students
40,000	910	2.25

4.2 Major concerns and issues of the students

From the students' perspective, some of the major reasons for not opting for the RE courses at PG level are mentioned below:

- The salary packages are found to be low at the entry level in the renewable energy jobs.
- There are wide disparities within the sub-sectors of RE (For example: Salary packages for Wind and Solar sub-sectors are much higher than Biomass sub-sector)
- Off take of RE students into the industry through campus selections is minimal. (E.g. in the year 2010, only 2 RE companies have conducted campus recruitment)
- There is a perception that the career prospects in RE sector are not so attractive, compared to conventional manufacturing industries and IT sector
- Awareness of the future growth potential of RE is low amongst the students.

There is a need to attract more number of students in RE sector. Following are few suggestions to be considered:

- The Govt. can consider providing monthly scholarship to PG level students in select universities. This will attract more number of students interested in pursuing their career in this sector
- RE job fairs should be organised at least once in a year in different metros. Industry associations, such as CII can organise these job fairs with support of MNRE and industry

The detailed recommendations are provided in Chapter 5.

4.3 Major concerns and issues of the institutions

While interacting with the institutions to identify the reason for lack of interest amongst students to undertake RE energy course, the following observations have emerged:

- Students who join the RE courses, do it out of their own passion in renewable energy.
- Campus interviews by reputed RE companies are non-existent or minimal, as compared to conventional industrial sectors. This could be one of the reasons for students not opting for RE courses

- In the absence of any scholarships from the Government of India, many of the institutions are finding it difficult to attract students
- Being a relatively new area, renewable energy education largely suffers due to unavailability of resources (e.g. trained faculty, suitable course materials, laboratories etc.,)

Following are few suggestions, which will help the institutions to overcome these issues:

- MNRE should fund at least 12 universities in the country at the rate of Rs. 2 Crores per university to develop / procure necessary infrastructural facilities such as lab equipment, training prototype models etc., for imparting RE education
- MNRE can consider providing scholarships to PG students opting for RE courses
- With the support of AICTE, MNRE should encourage more number of engineering colleges to offer renewable energy courses at PG level

The detailed recommendations are provided in Chapter 5.

4.4 Challenges faced by the industry

To understand the key reasons for low in-take of students in RE sector, CII had interaction with major RE industries. Following are the key points which emerged out of these discussions:

- University courses' curriculums do not meet the specific skill requirements of the RE industry. The curriculum of two institutions offering renewable energy courses is enclosed as Annexure-12. The curriculum must have greater focus on technology and design aspects. Also the institutions should provide extensive training and exposure on latest trends and technologies
- Some institutions absorb non-engineering graduates for PG courses in renewable energy. These students do not have sufficient engineering knowledge to meet the design and process requirements of the RE industry. Hence, the RE industry find it difficult to employ them
- There is a shortage of skilled ITI trained candidates who have exposure to RE
- The small and medium size RE industries face the problem of retaining candidates as the salaries of IT and manufacturing sectors are much higher

The issues faced by the industry can be addressed in the following ways:

- Enhancing the curriculum for PG students so as to include renewable energy technologies like Solar Parabolic Trough System, Solar Concentrated Hybrid Thermo-Photovoltaic System, Economics of Wind and Solar Systems etc.
- Encouraging ITIs to offer 3-6 months vocational training course on RE technologies with the support of industry, who can then be directly employed industry

The detailed recommendations are mentioned in Chapter 5.

Chapter 5
Recommendations

Based on findings of the study, it is evident that there is huge growth potential in Renewable Energy sector. The study also reveals that there are several challenges faced by the industry in meeting the human resource requirement of RE sector. This chapter recommends various HRD strategies to meet the demand of RE sector in immediate future.

The recommendations suggested are covered into two parts –

(i) General recommendations that are applicable across all sectors of renewable energy and

(ii) Sector-specific recommendations covering the various sub-sectors of Wind, Solar, Biomass, Biogas and Small Hydro.

5.1 General Recommendations

5.1.1 Facilitate interventions for attracting talent in RE sector

The study indicates that the number of RE companies conducting campus interviews for UG & PG students is very few. There is a need to strengthen the campus recruitment through following activities:

a. Industry Associations should facilitate partnerships between industry and universities and make industry commit for campus recruitment by signing MoU's with universities.

b. Universities should market themselves to attract more RE companies through brochures and job oriented campus training for students.

c. Progress of campus recruitments should be monitored by MNRE and industry associations jointly.

5.1.2 Consider providing stipend to PG level students in select universities.

A monthly stipend of INR 10,000/- can be given to each student opting PG course in RE. The stipend can be funded through government. Suggested target could be 100 students initially and later can be increased by 25% every year. Industry should also join hands with government in sponsoring students. This will encourage more students to opt for RE courses.

5.1.3 Organize Renewable Energy Job fairs

It is recommended to organize job fairs once in a year at 6 metros (Delhi, Mumbai, Kolkata, Chennai, Hyderabad & Bangalore). This facilitates interaction between industry and students to market each other. This model has been highly successful in other sectors like IT, Pharmaceuticals, etc.,

Industry associations such as CII can organize these job fairs with the support of MNRE and Industry.

5.1.4 Facilitate awareness and out-reach programs on RE

There is a need to proactively facilitate awareness and outreach programmes. The objective is to highlight job opportunities and career prospects and instill a sense of pride in RE jobs through:

a. Publicity campaign by the government / industry through talk shows, posters, advertisements in different media (viz. electronic, press etc.) such as "Join Army" campaign promoted by Ministry of Defence.

b. Organizing awareness programs in educational institutions by experts from various renewable energy industries – State renewable energy nodal agencies can facilitate this activity.

c. Large scale campaigns like conducting workshops / road shows in 6 major cities (Delhi, Mumbai, Kolkata, Chennai, Hyderabad & Bangalore). These road shows can later be extended to other cities. Industry associations with the support of MNRE and State Nodal Agencies can organize such workshops to attract RE students from various universities.

5.1.5 Encourage Industry – Institute partnerships in the country to develop manpower suitable to industry.

Industrial associations such as CII can facilitate partnerships between RE companies and leading institutions such as IIT's, NIT's etc., in:

a. Encouraging industry experts to work as visiting faculty in institutions. The industry experts can handle latest topics related to RE like Solar Parabolic Trough System, Solar Concentrated Hybrid Thermo-Photovoltaic System, Economics of wind and solar systems etc.

b. Developing database of Universities offering RE courses and hosting in MNRE & CII websites

c. Facilitating summer internships for UG & PG students on RE technology in industries. Industry should facilitate students in undertaking pilot projects.

5.1.6 Initiate pro-active steps to offer vocational training for ITI technicians:

Vocational training on RE for ITI candidates can make them better suitable to take up jobs in the RE industry. The following measures are suggested:

a) Industry should collaborate with ITI's and develop a 3 / 6 month vocational training courses on RE subjects. This should expose ITI technicians in module assembly, operation, installation and trouble shooting of RE equipment. Such candidates should be employable by industry soon after their vocational training

b) The above training courses can be developed in vernacular languages and training modules can be circulated to all ITI's to encourage more people from rural areas to opt for jobs in RE sector.

* *State nodal agencies can facilitate the above activities. They can also avail experience and services of institutes like Alternate Hydro Energy Centre (AHEC), Roorkee, Solar Energy Centre, New Delhi etc.,*

5.1.7 Promote collaboration between Indian universities and world-class universities abroad for adopting best practices in imparting RE skills

This will enhance the knowledge base of Indian institutes and keep abreast of latest technologies in RE sector.

Facilitate collaboration and networking Indian Universities with International Universities working in the areas of RE. Following are some of the successful examples of overseas universities specialized in RE technologies:

a. Wuppertal Institute for Climate, Environment and Energy, Germany

b. School of Photovoltaic and Renewable Energy Engineering, University of New South Wales, Australia

c. Centre for Energy Efficiency and Renewable Energy (CEERE), University of Massachusetts, USA

Industry and universities with the support of MNRE can organize international missions to such world-class universities to learn the best practices in RE technology. These best practices can be replicated in India.

5.1.8 Strengthen existing curriculum at UG and PG levels; Seek the support and intervention of AICTE to enhance syllabus so as to cover RE subjects:

A committee consisting members from MNRE, AICTE, national / international Universities and Industry should to be formed. This committee would focus on:

a. Developing curriculum for PG students focusing on RE technologies. This curriculum would be based on latest technologies, manufacturing practices and operational techniques.

b. Develop full time courses on RE at both UG and PG level in more number of Universities with highly focused content on design aspects.

c. Recruit experienced professors in educational institutions. To meet the salaries and other expenditure, MNRE may consider providing a one time grant to 15 top universities / institutions offering RE courses at the PG level.

d. Extend financial support to 15 universities offering RE courses at the PG level to upgrade laboratory and library facilities. MNRE may consider providing this assistance.

Enhance number of seats available at PG level in Universities. This will also encourage more students to join RE courses.

** The proposed committee can monitor progress of above activities.*

5.1.9 Facilitate adoption of RE technologies in innovative applications to create new green RE jobs. Several new technologies related to RE are at nascent stage. The development of these new technologies and large scale commercialization will result in major job opportunities.

Typical examples:

- Solar Air-conditioning systems
- Building Integrated Photo Voltaics (BIPV)
- In-situ wind turbines in building applications
- In-situ power generation by Fuel cells

MNRE can institute a separate study to identify areas and estimate the national benefits.

5.1.10 Develop skill-imparting tools on RE to enhance specific skills required in the RE industry

a. Encourage web-enabled RE education and Distance Education Programs in RE technologies (Eg. Centre for Distance Education Programme at IIT Bombay).

b. Establish simulator based training facilities in the country to train students and new recruits in the industry

5.1.11 Develop 1,000 'Accredited Trainers' for RE in the country by 2015, who can impart skill-based training

CII with the support of MNRE and industry can develop modules and offer "Training of Trainers (ToT)" programs. The accredited trainers can train industry personnel, lecturers and consultants. Such programs can be developed for various sectors of RE. This would facilitate having a large pool of trainers to develop people in RE aspects

5.1.12 Incubate and hand-hold 500 green entrepreneurs involved in manufacturing of RE products and technologies by 2015, to create new RE jobs

a) Strengthen banks, financial institutions and venture capitalists by creating awareness on potential for growth in RE sector thereby creating more jobs.

b) Allocate specific funds / loans through IREDA and other nationalized banks to encourage new SME s in RE and existing SME s for scaling up their operations.

c) Conduct special training programs nation wide on green entrepreneurship, with specific focus on RE.

d) Introduce channels and micro-financing systems to facilitate individuals to buy RE related products thereby creating a demand for higher manufacturing capacity.

e) Proactively create jobs through setting up of RE parks throughout the country on the lines of Green SEZ's.

** Industry with the support of MNRE can facilitate incubation of Green Entrepreneurs.*

5.1.13 Establish a Centre of Excellence in Renewable Energy to steer a national movement which can facilitate creation of new RE jobs

This can be achieved through a Public private partnership (PPP) with the involvement of government and private industry. The centre would be managed independently.

The vision of the Centre of Excellence would be to catalyze RE movement in India. The broad agenda would be to focus on services related to Training, Awareness, Accreditation, Incubation, Demonstration centres and other advisory services for the promotion of RE.

Industry association like CII with the support of MNRE and local government can set up the Centre of Excellence

5.1.14 To implement all the suggestions, it is recommended to form a high level committee led by MNRE. The committee would comprise of all stakeholders of the RE sector viz., Government, Nodal agencies, Users, Manufacturers, Academia etc., The activities of the committee can be facilitated and coordinated by CII.

5.2 Sector-Specific Recommendations for Addressing Skill Gaps

5.2.1 Wind Energy

Wind based renewable energy generation in India currently offers about direct employment and 28,000 indirect employment opportunities. The typical job profiles would be highly qualified electrical, mechanical & materials engineers, semi-skilled and non-skilled workers for the production chains, technical staff for the O&M, project managers, environmental engineers and other specialists to analyze the environmental impacts of wind farms, meteorologists for wind energy forecasts and prediction models, etc

This would pose severe crunch on the wind energy sector as the growth opportunities of the sector could be hampered significantly if the skill requirements are not met. The following are some of the recommendations to address this skill gap:

Skill Gaps	Recommendations
Project Development & Consultancy ❖ Design techniques to match wind resource availability with appropriate rating of wind energy installations ❖ Skills in optimization of blade angles for maximizing energy output **Construction & Installation** ❖ Installation of high capacity wind turbines **Operation & Maintenance** ❖ O & M of turbines and gearboxes ❖ Failure analysis of gearboxes of wind turbines **Marketing** ❖ Techno-commercial marketing of wind projects	**1. For industry professionals** a. Train industry professionals in simulation techniques for assessing wind energy generation potential through international experts / organizations **2. For ITI technicians** a. Launch wind energy specific three / six month certification courses in ITI in partnership with wind industry. This course would provide exposure in the areas of construction & installation, O & M and technical troubleshooting of wind turbines **3. For UG & PG institutions** a. Facilitate partnerships between wind energy companies and leading institutions such as IITs, NITs, etc to work in the following areas – Industry experts as faculty, joint research projects, internship of students b. Introduce techno-commercial analysis and marketing skills as part of syllabus in post-graduate RE curriculum through AICTE

5.2.2 Solar PV & Solar Thermal

Solar PV & Solar Thermal based renewable energy generation in India currently contributes significantly to the employment opportunities in the renewable energy sector. Considering the JNNSM targets, there would be a multi-fold increase in employment opportunities in this sector.

Employment opportunities in Solar PV & Solar thermal based RE systems require qualified mechanical & electrical engineers, semi-skilled and non-skilled workers for installation & commissioning, technical staff for the O&M, project managers, etc.,

Skill Gaps	Recommendations
Manufacturing ❖ Not adequately skilled in module assembly ❖ System integration in solar PV **Construction & Installation** ❖ Installation and commissioning of solar thermal systems (SWH). ❖ Third-party installers not skilled in erection and installation ❖ Grid integration of mega watt scale solar PV power projects **Operation & Maintenance** ❖ Shortage of skills in trouble shooting of circuitry of solar PV lanterns and home lighting systems **Marketing** ❖ After sales service, customer care ❖ Techno-commercial analysis of mega projects in on-grid solar **R & D** ❖ Knowledge and exposure in advanced areas like wafer technology, semi conductor technology. ❖ Design skills in installing BIPV in buildings	**1. For industry professionals** a. Train industry professionals in grid integration skills, BIPV, Solar air-conditioning and troubleshooting through international experts / organizations **2. For ITI technicians** a. Launch solar energy specific three / six month certification courses in ITI in partnership with solar industry. This course would provide exposure in the areas of construction & installation, module assembly, O & M and technical troubleshooting of Solar plants **3. For UG & PG institutions** a. Facilitate partnerships between Solar energy companies and leading institutions such as IITs, NITs, etc to work in the following areas – Industry experts as faculty, joint research projects, internship of students b. Introduce techno-commercial analysis and marketing skills as part of syllabus in post-graduate RE curriculum through AICTE

❖ Project Development & Consultancy ❖ Lack of awareness & experience in handling concentrated solar collectors (CSP).PV	

5.2.3 Biomass

Biomass has been a key player in meeting rural India's energy needs for a long time. Biomass based RE power generation has some unique features / attributes to deal with. Employment in this sector is largely unorganized in nature as a large number of job opportunities exist in biomass collection, handling & preparation. Biomass can offer significant rural employment generation opportunities.

The typical job profiles would be highly qualified mechanical, electrical & thermal engineers, semi-skilled and non-skilled workers for biomass collection, handling & processing, technical staff for the O&M, project managers, environmental engineers and other specialists, etc.,

Skill Gaps	Recommendations
Manufacturing ❖ Design and fabrication skills in biomass gasifiers ❖ Hot gas conditioning systems in biomass gasifiers ❖ Standard design and processes in designing biogas plants **Construction & Installation** ❖ Erection & commissioning of large scale, on-grid biomass power projects. **Operation & Maintenance** ❖ Exposure in handling biomass-based combustion systems in large scale biomass projects ❖ Maintenance and repair of fuel-handling systems ❖ Feed stock planning and logistics involved in biomass collection	**1. For industry professionals** a. Train industry professionals in combustion, fuel handling & processing and troubleshooting through national experts (from thermal power sector) international experts / organizations b. Services of specialized institutes such as National Power Training Institutes, etc could be availed for training in Biomass sector **2. For ITI technicians** a. Launch biomass energy specific three / six month certification courses in ITI. This course would provide exposure in the areas of collection, handling & processing of biomass, power generation, O & M and technical troubleshooting of biomass power plants

Marketing ❖ Developing and mentoring village-level franchisee networks. ❖ Techno-commercial marketing skills ❖ Vendor development	**3. For UG & PG institutions** a. Facilitate partnerships between Biomass energy companies and leading institutions such as IITs, NITs, etc to work in the following areas – Industry experts as faculty, joint research projects, internship of students b. Introduce techno-commercial analysis and marketing skills as part of syllabus in post-graduate RE curriculum through AICTE **4. Community** a. Develop training material for village level operators in vernacular languages on biomass gasifiers, handling & preparation of biomass. Gasifiers installed for remote village electrification are to be operated by the locals after extensive training

5.2.4 Biogas

Biogas technology provides an alternate source of energy in rural India, and is considered as an appropriate technology that meets the basic need for cooking fuel in rural areas. Using locally available resources such as cattle waste and other organic wastes, energy and manure are derived to meet livelihood opportunities in rural communities.

Biogas based RE power generation has some unique features / attributes to deal with. The size of the biogas plants have a wide variation in its capacity, varying from 2 cu.m to 1000 cu.m in size. Majority of the biogas plants are owned & operated by individuals. Installation of the biogas plants are largely carried out by local masons based more on their experience rather than expertise or skill.

The typical job profiles would be highly qualified mechanical, electrical engineers, semi-skilled and non-skilled workers for organic waste collection, handling & processing, technical staff for the O&M, project managers, environmental engineers and other specialists, etc

Skill Gaps	Recommendations
Design ❖ Exposure and awareness on standard designs **Operation & Maintenance** ❖ O & M of biogas plants ❖ Best practices	**1. For industry professionals** a. Industry professionals should train local community on installation, operation and maximizing biogas generation from biogas plants **2. For ITI technicians** a. Launch biogas energy specific three / six month certification courses in ITI. This course would provide exposure in the areas of installation, erection & commissioning of biogas plants, O & M and technical troubleshooting of biogas plants **3. For UG & PG institutions** a. Introduce techno-commercial analysis and marketing skills as part of syllabus in post-graduate RE curriculum through AICTE **4. Community** a. Develop training material for village level operators in vernacular languages on biogas plants.

5.2.5 Small Hydro Power Plants

Hydropower is recognized as a viable renewable source of energy, which is economic, non-polluting and environmentally benign. The location of small hydro power plants would typically be remote rural areas, where the site conditions permit installation of these power plants. Owing to the location disadvantage, it is very difficult to attract & retain talent in this sector.

The typical job profiles would be highly qualified mechanical & electrical engineers, technical staff for the O&M, project managers, environmental engineers and other specialists, etc

Skill Gaps	Recommendations
Project Development & Consultancy ❖ Feasibility and assessment potential of small hydro projects ❖ Global Information System (GIS) / Global Positioning System (GPS) based planning of hydro projects **Operation & Maintenance** ❖ Assembly and troubleshooting of small hydro turbines	**1. For industry professionals** a. Train industry professionals in feasibility & assessment potential, GIS / GPS, technical troubleshooting, etc through international experts / organizations **2. For ITI technicians** a. Launch small hydro energy specific three / six month certification courses in ITI. This course would provide exposure in the areas of installation, erection & commissioning of small hydro power plants, O & M and technical troubleshooting. This course could be organized in close co-ordination with Alternate Hydro Energy Centre (AHEC), IIT, Roorkee **3. For UG & PG institutions** a. Introduce techno-commercial analysis and marketing skills as part of syllabus in post-graduate RE curriculum through AICTE

ANNEXURES

Annexure 1

Estimation of Employment in Wind Energy Sub-sector

- The approximate number of people in few top wind energy companies in India, obtained through visits and interactions is as shown below.

Sl No	Company	Employment
1	Company A	8,000
2	Company B	3,700
3	Company C	550
4	Others	1,750 *
	Total	**14,000**

* Ten small wind companies each employing 150-200 people (175 x 10 = 1750)

- Total direct employment in wind energy sector = 14,000
- Every direct job in wind energy creates approximates two indirect jobs (Note: Feedback from the wind industry) ie. 14,000 x 2 = 28,000 jobs

  Indirect Employment through Blade, gear box, bearing and motor manufacturers, suppliers of grid connectivity electrical equipment, etc.,
- Total Employment = Direct + Indirect = 14,000 + 28,000 = **42,000**

Type of Employment	Employment	Functional Area of operation	Percentage of people employed (%) *
Direct	14,000	Manufacturing	20
		O & M	25
		Project Development	30
		Marketing	25
Indirect	28,000	-	-
Total	**42,000**	**-**	**100**

*** These breakups are only indicative and may vary from company to company**

Annexure 2

Estimation of Employment in Solar PV On-grid Sub-sector

- Typical size of each power plant = 1 to 3 MW
- Number of direct employment in each unit = 3 people *
- Number of indirect employment in each unit = 3 people *
  Indirect Employment: Grid connectivity electrical equipment manufacturers, DC to AC converters, cables, etc.,
- Total employment / unit = Direct + Indirect = 3 + 3 = 6
- Total installed on-grid power = 6 MW (in 3 units)
- Current employment = 6 people / unit x 3 units = 18 (say **20**)

* Based on information obtained from 3 MW project in Kolar Dist, Karnataka.

Annexure 3

Estimation of Employment in Solar PV Off-grid Sub-sector

- Current capacity for solar panel manufacturing (export market) = 800 MW
- Direct employment / MW of solar panels produced = 30
  (Based on industry survey)
- Indirect employment / MW = 60
  (Based on survey with manufacturers in India)

  Indirect Employment through dealers, marketing staff of dealers, lantern manufacturers, solar home lighting kits, battery manufacturers, lamp manufacturers, etc.,
- Total employment / MW = Direct + Indirect = 30 + 60 = 90
- Manufacturing in 2009 in the country = 800 MW *(Source: MNRE)*
- Number of people employed = 90 x 800 = **72,000**
- Approximate break up across different functional areas *(Based on industry survey)*

Type of Employment	Employment	Functional Area of operation	Percentage of people employed (%) *
Direct	24,000	Manufacturing	20
		Installation	10
		O & M	20
		Marketing	40
		Others	10
Indirect	48,000	-	-
Total	**72,000**	**-**	**100**

*** These breakups are only indicative and may vary from company to company**

Annexure 4

Estimation of Employment in Solar Thermal Sub-sector

Case study of Manufacturer A	
Installed Capacity	: 25,000 sq.m per annum
Total employment	: 150
No of dealers	: 180

Case study of Manufacturer B	
Installed Capacity	: 4,000 sq.m per annum
Number of people employed	: 10
Number of dealers	: 5

Direct Employment

- Number of large-scale manufacturers (> 25,000 sq.m / annum) = 10
- Average employment in each large-scale company (Direct) =150
- Direct employment in large-scale companies = 10 x 150 = **1,500**
- Number of small and unorganised manufacturers = 150 (approx)
- Average employment in each small scale company = 10 (approx)
- Direct employment in small-scale companies = 150 x 10 = **1,500**
- Total Estimated Direct Employment in Indian solar thermal sub-sector = Large-scale + Small-scale = 1500 + 1500 = **3,000**

Indirect Employment

- Average number of dealers for each large company = 180 (approx)
- Total number of dealers for large companies = 180 x 10 = 1800
- Number of dealers for each small company = 5 (approx)
- Total number of dealers for small companies = 5 x 150 = 750
- Total estimated number of dealers = 1800 + 750 = **2550**
- Estimated employment with each dealer = 10 (approx)
- Commission agents with each dealer = 5 (approx)
- Total employment with each dealer = 10 + 5 = **15**
- Total Estimated Indirect Employment = 2550 x 15 = **38,250**
- Total Estimated Employment in Solar Thermal Sub-sector = Direct + Indirect
  = 3000 + 38250
  = 41,250 (Say **41,000**)

Annexure 5

Estimation of Employment in Biomass On-grid Sub-sector

Case Study: Company M	
Existing capacity (Biomass combustion power plant)	: 4.5 MW
Direct employment	: 90
Estimated indirect employment in fuel collection and handling	: 170

Note: The number of people employed in biomass power plants ranging between 4 and 8 MW is almost the same.

- Normal size of biomass combustion plant on-grid is considered as 6 MW
- Direct employment to operate a power plant of 6 MW size = 90 people *
- Generally on the higher side, nearly 40 % of the people will be skilled manpower taking care of important machinery such as boilers, turbines, alternators, etc.,
- Skilled employment / unit = 90 x 0.4 = 36 people
- Unskilled employment / unit = 90 – 36 = 54 people
- Indirect employment for a 6 MW plant = 170
  (Based on survey with manufacturers in India)

  Indirect Employment: Fuel collection, handling and processing, etc.,
- Total employment generation for a 6 MW power plant = 90 + 170 = 260 / plant
- Installed capacity in India = 820 MW
- Estimated number of plants = 820 / 6 = 137 plants
- Skilled employment in the sector = 137 x 36 = 4932 (Say **5000**)
- Unskilled direct employment = 137 x 54 = 7398 (Say **7000**)
- Unskilled indirect employment = 137 x 170 = 23,290 (Say **23,000**)
- Total employment (Direct + Indirect) in the sector = 5000 + 7000 + 23000 = **35,000**

Note: Employment in manufacturing is not considered here, as the conventional power plant equipment manufacturing industry can absorb this capacity.

Annexure 6

Estimation of Employment in Biomass Gasifier Sub-sector

Number of people in operations

- Total installed capacity (cumulative) in the country = 108,370 KW
- Typical size of each installation of biomass gasifier is considered as 20 KW
  (Feedback from leading biomass gasifier manufacturing companies)
- Number of installations = 108,370/ 20 = 5,418
- Number of people in operations = 4 people / installation
- Employment in operations = 5,418 x 4 = 21,672

Number of people in manufacturing

- Current annual addition in capacity = 2,910 KW
  (Source: MNRE Annual Report 2009)
- Typical size of each installation = 20 KW
- Number of installations added per year = 2910 / 20 = 145 plants / year
- Number of people in manufacturing = 2 people / installation
- Employment in manufacturing = 145 x 2 = **290**
- Total employment = Employment in operations + Employment in manufacturing
  = 21672 + 290
  = 21962 (Say **22,000**)

Annexure 7

Estimation of Employment in Biogas Sub-sector

Case Study based on information from a Nodal agency
Breakup for the construction of a family sized biogas plant
Masons (man-days) : 8
Turnkey installers (man-days) : 8
Contract labour (man-days) : 16

Total man-days : 32 (Say 30)

- Number of new installations added per year = 16,000 (*Source: MNRE*)
- Mandays required / installation = 30
- Number of plants that can be installed / person / year = 240 (days/year) / 30 = 8
- Present estimated direct employment = 16,000 / 8 = 2,000
- Employment in servicing
  - Number of plants handled by 1 person / year = 50 (*Industry feedback*)
  - Total number of plants installed = 4,120,000 (*Source: MNRE)*
  - Estimated total employment in servicing = 4,120,000 / 50 = 82,400
- Estimated total employment = 2,000 + 82,400 = 84,400 (Say **85,000**)
- The entire 85,000 jobs have been categorised as semi-skilled employment

Annexure 8

Estimation of Employment in Small Hydro Sub-sector

Case Study: Company B P	
Total capacity	: 97 MW
Direct employment on date	: 460
Specific direct employment / MW	: 3 to 5
Ratio of direct to indirect employment	: 4: 1

- Cumulative installed capacity = 2,500 MW
- Direct employment = 4 / MW*
- Indirect employment = 1 / MW*
- Total employment / MW = 4 + 1 = 5 *(Source: From industry)*
- Total employment = 2500 x 5 = **12,500**
- Current addition in capacity in 2008 = 91 MW
- Growth rate of the sector = (91 / 2500) x 100 = 3.6 % (Say **4 %**)

Note: Employment in the manufacturing of small hydro turbines, alternators, etc., is not considered because the conventional industry can cover the capacity increase.

* Feedback from the industry

Annexure 9

Estimation of Employment in Aero-Generators/Hybrid Systems and Wind Pumps

- Majority of companies engaged are small companies each employing a handful of people.
- Currently there are very few installations in the country.
- The growth projections are not available.
- The total employment (direct + indirect) in this sub-sector is less than **1000***

* Feedback from manufacturers of Aero-generators and Wind mill pumps

Annexure 10

State-Wise Details of the Colleges Offering RE Courses

Sl No.	Name of the State	No. of Engineering Colleges	No. of Colleges offering Courses on RE in PG level
	Central		
1	Madhya Pradesh	61	4
2	Chhattisgarh	14	1
3	Gujarat	37	-
	Eastern		
4	Mizoram	1	-
5	Sikkim	1	-
6	West Bengal	54	4
6	Tripura	1	-
7	Meghalaya	1	-
8	Arunachal Pradesh	1	-
9	Andaman&Nicobar	-	-
10	Assam	3	1
11	Manipur	1	-
12	Nagaland	-	-
13	Orissa	41	-
14	Uttarakhand	4	2
15	Jharkhand	10	-
	North		
16	Bihar	8	-
17	Uttar Pradesh	89	4
18	Uttranchal	9	-
	North-west		
19	Chandigarh	5	1
20	Haryana	38	1
21	Himachal Pradesh	5	-
22	Jammu& Kashmir	5	1
23	New Delhi	14	2
24	Punjab	45	-
25	Rajasthan	41	4

	South		
26	Andhra Pradesh	236	8
27	Pondicherry	6	1
28	Tamil Nadu	254	13
29	Karnataka	118	5
30	Kerala	89	1
	West		
31	Maharashtra	155	4
32	Goa	3	-
33	Daman & D,Dadar,N.H.	-	-
	Total	**1346**	**52**

Source: AICTE Web Data (www.aicte-india.org)

Annexure 11

List of Educational Institutes offering Courses on Renewable Energy (Post Graduate Level)

Sl	Institute	Course	Subject	Seats
1	*University of Lucknow, Lucknow (www.lkouniv.ac.in)*	**M.Sc**	Renewable Energy	25
2	*University of Kota, Kota (www.uok.ac.in)*	**M.Sc, M.Sc Tech**	Energy Studies	40
3	*University of Pune, Pune (http://www.unipune.ac.in/)*	**M.Tech**	Energy Studies	20
4	*Indian Institute of Technology, New Delhi (www.iitd.ac.in)*	**M.Tech**	Energy Studies, Energy & Environment Management	25
5	*Devi Ahilya University, Indore (www.seec.dauniv.ac.in)*	**M.Tech, M.Phil**	Energy Management, Energy and Environment	36
6	*Indian Institute of Technology, Bombay (www.iitb.ac.in)*	**M.Tech**	Energy Science and Engineering	
7	*Vellore Institute of Technology, Vellore (www.vit.ac.in)*	**M.E**	Energy Systems Engineering	25
8	*National Institute of Technology, Tiruchirappalli (www.nitt.edu)*	**M.Tech**	Energy Engineering	18
9	*National Institute of Technology, Calicut (www.nitc.ac.in)*	**M.Tech**	Energy Management	18
10	*Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal (www.rgtu.net)*	**M.Tech**	Energy and Environment Management	18
11	*Maulana Azad National Institute of Technology, Bhopal (www.manit.ac.in)*	**M.Tech**	Energy Engineering	31
12	*Jadavpur University, Jadavpur (www.jadavpur.edu)*	**M.Tech, Certificate**	Energy Science and Technology, Energy Management and Audit	10
13	*Allahabad Agricultural Institute (Deemed University), Allahabad (www.aaidu.org)*	**M.Tech, PGD**	Energy Management, Renewable Energy	20
15	*University of Rajasthan, Jaipur (www.uniraj.ernet.in)*	**M.Phil, Ph.D**	Energy	20
16	*Government Engineering College, Raipur, Chhattisgarh (http://www.gecraipur.ac.in/)*	**M.E**	Energy Systems & Pollution	13
17	*Malaviya National Institute of Technology, Jaipur (http://www.mnit.ac.in/)*	**M.E**	Energy Engineering	18
18	*Kumaraguru College of Technology, Coimbatore (www.kct.ac.in)*	**M.E**	Energy Engineering	18
19	*Annamalai University, Chennai (www.annamalaiuniversity.ac.in)*	**ME, PGD, Diploma**	Energy Engineering & Management, Electrical Energy Management and Energy Audit	25
21	*Maharana Pratap University of Agriculture and Technology, Udaipur* (*www.mpuat.digitaluniversity.ac*)	**M.E**	Renewable Energy Sources Engineering	06
22	*Sharada Group of Educational Institutions, Mathura (www.sgei.org*)	**MBA**	Renewable Energy Resources and Energy	

			Management	
23	*National Engineering College, Kovilpatti (http://www.nec.edu.in/)*	**M.E**	Energy Engineering	18
24	*Punjab University, Chandigarh (http://www.puchd.ac.in/)*	**M.Tech**	Energy Engineering & Management	25
25	*University of Petroleum and Energy Studies, Dehradun (www.upes.ac.in)*	**M.Tech**	Energy Systems	
26	*Centre for Energy Studies, JNTU College of Engineering, Hyderabad (www.jntuceh.ac.in/dodes.htm)*	**M.Tech**	Energy Systems	18
27	*Periyar Maniammai College of Tech. for Women, Periyar Nagar, Thanjavur, Tamil Nadu (http://www.pmu.edu/)*	**M.Tech**	Renewable Energy	18
28	*S.V University College of Engineering, Tirupathi (http://www.svuniversity.in/colleges/eng/main.html)*	**M.Tech**	Energy Management	18
29	*Rajiv Gandhi College of Engineering Research & Technology, Chandrapur (www.rcert.ac.in)*	**M.Tech**	Energy Management System	18
30	*Kurukshetra University, Kurukshetra (www.kuk.ac.in)*	**M.Tech**	Environment & Energy Management	
31	*Indraprastha University, New Delhi (http://ipu.ac.in/)*	**M.Sc**	Environment Management	
32	*Vignan University, Guntur (www.vignanuniversity.org)*	**M.Tech**	Energy Engineering	
33	*Kalasalingam University, Virudhunaga, TN (www.kalasalingam.ac.in)*	**M.E**	Energy Engineering	43
34	*PSG College of Technology, Coimbatore (www.psgtech.edu)*	**M.Tech**	Energy Engineering	18
35	*Indian Institute of Social Welfare and Business Management, Kolkata (www.iiswbm.edu)*	**M.Tech**	Energy Management	
36	*BV Bhoomaraddi College of Engineering & Technology, Hubli (www.bvb.edu)*	**M.Tech**	Energy Systems Engineering	18
37	*National Institute of Technology, Surathkal (www.nitk.ac.in)*	**M.Tech**	Power & Energy Systems	17
38	*Indian Institute of Technology, Roorkee (http:// www.iitr.ac.in)*	**M.Tech**	Alternate Hydro Energy Systems	18
39	*Bengal Engineering & Science University, Shibpur (www.becs.ac.in/civil.html)*	**M.E**	Geo-technical Engineering, Environmental Engineering	19
40	*JNTU College of Engineering, Anthapur (http://www.jntucea.org/)*	**M.Tech**	Energy Systems	18
41	*Pondicherry Engineering College, Pondicherry (http://home.pec.edu/index.html)*	**M.Tech**	Energy Technology	17
42	*NMAM Institute of Technology, Nitte (http://www.nitte.ac.in/index.php)*	**M.Tech**	Energy Systems Engineering	18
43	*Anna University, Chennai (http://www.annauniv.edu/)*	**M.E**	Energy Engineering	36
44	*Banaras Hindu University, Uttar Pradesh*	**M.Tech**	Energy Engineering	30

	(http://www.bhu.ac.in/)			
45	*SJ College of Engineering, Mysore (www.sjce.ac.in/)*	**M.Tech**	Energy Systems & Management	18
46	*Shri Mata Vaishno Devi University(SMVDU), Katra, J&K (http://smvdu.net.in/progcourseitrmmenu)*	**M.Tech, Ph.D**	Energy Management, Energy Security	15
47	*TERI University, New Delhi (www.**teri**in.org)*	**M.Tech, Ph.D, PGD**	Renewable Energy Engineering and Management, Energy Technology	30
48	*C Abdul Hakeem College of Engineering & Technology, Vellore (www.cahcet.in)*	**M.E**	Energy Engineering	18
49	*Tezpur University, Tezpur(www.tezu.ernet.in)*	**M.Tech, Ph.D**	Energy Technology	18
50	*Amity University, Noida (http://www.amity.edu /)*	**M.Tech**	Solar and Alternative Energy	
51	*University of Lucknow, Lucknow (http://www.lkouniv.ac.in/courselist.asp)*	**M.Sc**	Renewable Energy	30
52	*Gandhigram Rural University, Gandhigram (www.ruraluniv.ac.in)*	**M.Phil**	Energy Studies	
53	*College of Technology and Engineering, Udaipur* (www.ctae.ac.in)	**Ph.D**	Renewable Energy Sources	
54	*Aligarh Muslim University, Aligarh (www.amu.ac.in)*	**Ph.D**	Renewable sources of Energy	
55	*Tamilnadu Agricultural University, Coimbatore* (www.tnau.ac.in)	**B.Tech**	Energy and Environmental Engineering	
56	*Sinhgad Educational Society, Pune* (www.sinhgad.edu)	**B.E**	Energy	
57	*Indira Gandhi National Open University, New Delhi* (http://www.ignou.ac.in/)	**Diploma**	Renewable Energy Technologies	
58	*University of Hyderabad, Hyderabad (www.uohyd.ernet.in)*	**PGD**	Energy Management	
59	*Maharashtra Institute of Technology, Pune (www.mitpune.com)*	**PGD**	Energy Management	
60	*PCS India - Precise Cosultancy Services* (www.pcsindia.in/mitsde/mitsde.html)	**PGD**	Energy Management	
61	*MIT School of Distance Education, New Delhi, Bangalore (www.mitsde.com/study_center.asp)*	**PGD**	Energy Management	
	TOTAL			**910**

Source: List of Approved Post Graduate Education and Research institutions, AICTE (www.aicte-india.org)

Annexure 12

12.1 Course Structure of Energy Engineering as per AICTE Guidelines

- **Introduction**

  Trends of energy consumption, developed and developing countries, sources of energy, conventional and renewable. Fossil fuel, availability and limitations. Need to develop new energy sources-energy conservation methods, energy audit.

- **Solar Energy**

  Solar insulation calculations. Flat plate and concentrating collectors for liquid and gases, construction.

- **Collector Area Calculations**

  Heat removal factor, efficiencies.

- **Solar Systems**

  Power plants, low temperature and high temperature plants, solar driers, solar cookers, solar refrigeration systems.

- **Wind Energy**

  Types of rotors, horizontal axis and vertical axis systems, system design and site selection.

- **Biogas Plants**

  Types, parameters affecting plant performance, plant design.

- **Total Energy Conversion**

  Total energy concepts, Tidal plants, Cogeneration plants, Geothermal plants.

- **Direct Energy Conversion**

  Fuel cells, Thermoelectric, Thermionic and MHO systems

12.2 Course Structure of M.Tech - Energy Management at Sri Mata Vaishno Devi University, Katara, J&K

Semester I

- Applied Mathematics for Energy Management
- Fuel Technology
- Quantitative Methods for Energy Management and Planning
- Energy Economics and Planning
- Technology Forecasting and Assessment

Semester II

- Energy and Environmental Auditing
- Environmental Science and Engineering
- Non Conventional Energy Sources
- Industrial Energy Management
- Project evaluation and Management

Semester III

- Industrial waste management
- Fuel cell and Hydrogen energy
- Energy conservation
- Power plant engineering
- Program elective I

Semester IV

- Energy storage
- Program Elective II
- Open Elective
- Minor project

Semester V

- Major Project

Program Electives I & II

- Energy efficiency in buildings
- Wind and small hydro systems
- Solar passive architecture
- Decentralized generation systems
- Pollution control in power plants

Open Electives

- Demand side management of energy

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