Internal Review Report

Centre for Energy Studies

Indian Institute of Technology Delhi

New Delhi – 110 016

February 2014

CENTRE FOR ENERGY STUDIES

Preamble

Energy manifests itself in a variety of different forms and plays a central role in our lives. Prevailing globally adopted strategies of economic development are essentially based on excessive consumption of energy derived from fossil fuels. Moreover, for the required improvement in the quality of lives of the large population living in developing countries, it is necessary to substantially enhance per capita energy availability. The rapid escalation of global crude oil prices is bound to increase the pressure on oil importing developing countries with respect to foreign exchange requirement and balance of payments. Moreover, the adverse environmental impacts of fossil fuel extraction, conversion and utilization have also posed serious sustainability related threats before the mankind. With a phenomenal expansion of energy industries the technical occupation assoiated with energy extraction, conversion, transmission, distribution and utilization have changed considerably.

Environmental sustainability has become one of the main themes while discussing the future energy supply. Global aspects such as 'greenhouse effect' or 'protection of the earth's atmosphere' are being considered seriously. One has to consider ways and means of reducing or completely avoiding the environment polluting emissions at each stage of energy conversion processes. Energy supply and environmental protection is an inseparable unit and an energy engineer will have to take cognizance of the same. Technology evaluation and community acceptance determine his work and his consciousness in the same measure as the dominance of his technical ability.

In view of the above, a new generation of 'Energy Engineers and scientists' is required to develop, install, operate and maintain sustainable energy solutions for meeting the rapidly increasing energy demand of the society. Interdisciplinary manpower possessing different combinations of technical knowledge and skills are required to face the challenging tasks associated with providing sufficient energy to the increasing global population in a sustainable manner. The scientists and engineers, in the field of energy are required for a variety of occupations in following areas:

(a) Research and development institutions

(b) Organizations involved in energy extraction, conversion, transmission and distribution

(c) Service organizations (e.g. for energy auditing)

(d) Industrial and commercial organizations

(e) Manufacture, sale, installation of energy equipments

Realizing the need for education and research in the field of energy, Government of India established a national Centre for Energy Stuies (CES) at the Indian Institute of Technology Delhi in the year 1976. Research and development activities on various relevant aspects of conventional as well as non-conventional energy sources were initiated and suitable infrastructure established in its formative years.

In response to the demand from industrial and other organizations for trained manpower in the interdisciplinary field of energy, a regular M.Tech. Programme in Energy Studies has been offered at the CES since 1981. In order to accommodate the requests of many organizations for offering an M. Tech. course in the field of energy outside the normal working hours, an evening part time programme was started in 1989 which was subsequently revised to an M.Tech. Programme in Energy and Environment Management in 1998.

1. Curriculum

1.1 List of degree programmers offered - UG + PG - and enrollment.

UG None

Year	M. Tech in Energy Studies	M. Tech in Energy and Environment Management	Ph. D
2009-2010	43	82	102
2010-2011	58	107	91
2011-2012	55	92	95
2012-2013	60	81	110
2013-2014	66	83	116

(a) The Centre for Energy Studies (CES) offers the following interdisciplinary post-graduate programmes, leading to the award of M.Tech degree.

(i) M.Tech. in Energy Studies - This is a full time M.Tech programme for engineering graduates
and science postgraduates being offered since 1981. It is the first M. Tech. programme in the field of energy in the country.

(ii) M.Tech. in Energy and Environment Management - This is Part time M.Tech programme.
The programme is designed to facilitate the employed personals in public/private sector, research and development organizations and academic institutes to pursue higher studies on part-time basis (with classes held in evening) along with their jobs. The programme started in 1989 and revised in 1998

(b) **Ph. D. Programme:** The Centre offers Ph. D. programme in the areas of Renewable Energy, Internal Combustion Engines, Alternative Fuels, Emission Control, Electrical Energy Systems, Wind and Small Hydro Energy Systems, Heat and Mass Transfer, Solar Refrigeration and Air-conditioning, Solar Thermal Utilization, Solar Photovoltaic, Thin Film Technology, Energy and Environment, Energy Policy and Planning, Energy Economics, Fuel Technology, Solid Waste Interaction Management, Coal De-ashing, Combustion/ Incineration, Waste Effluent Treatment, MHD, ESP, Plasma Science and Technology.

1.2 Consistency of curricula with academic vision of the department.

The vision of the Centre is to contribute to the nation and world through excellence in education and research, in the field of energy and environment, to develop interdisciplinary manpower possessing different combinations of technical knowledge & skills required to face the challenging task of
providing sufficient energy to the increasing population in a sustainable manner.

In view of the above the Centre offers the interdisciplinary post-graduate programmes, leading to the award of M. Tech degrees.

1.3 Quality of programmes:

(a) Periodicity of curriculum review UG and PG (*relevant documents*).

Every year the course contents of M.Tech. programmes in Energy studies and Energy and Environment Management are being reviewed. However, major revisions in the course contents were made on 23rd July, 2009. The courses were revised keeping in view the current need in the areas of energy and environment.

(b) Mechanism for review at UG and PG level (*relevant documents*).

The programme were reviewed as per the recommendations of the members of programme advisory committee (PAC) and programme executive committee (PEC) and the external subject experts invited from various academic and research institutes and industry.

(c) Coursework for each UG, PG and PhD programme - Core / Elective.

	Core (PC)	**Elective (PE)**	**Open Elective (OC)**	**Total**
M. Tech in Energy Studies	42	12	6	60
M. Tech in Energy and Environment Management	45	9	6	60

More details of the programmes are attached in the Annexure 1.
Along with the above, following UG courses are offered as open electives.

Course Number	Name of the Course
ESL300	Self-organizing Dynamical System
ESL330	Energy, Ecology and Environment
ESL340	Non-Conventional Source of Energy

ESL350	Energy Conservation and Management
ESL360	Direct Energy Conversion Methods

(d) Pre PhD courses offered (*in last 5 yrs*).
PhD students choose courses relevant to their area of research from the courses offered in the centre and across the departments for M.Tech programmes.

(e) New advanced Masters / Pre-PhD courses introduced in last 5 yrs.

S.No	**Course No.**	**Course Title**
1.	ESL-734	Nuclear Energy
2.	ESL737	Plasma Based Material Processing
3.	ESL-746	Hydrogen Energy
4.	ESL-755	Solar Photovoltaic Devices and Systems

(f) Overlap between courses (c) and (d) & (e), including opening latter to UG.

Within allowable limits

(g) Seminar series (weekly/regular) held each semester (*provide list*).

- Majority of the external experts visiting the Centre deliver lectures that are attended by faculty and students. A seminar series involving doctoral students is being initiated.

(h) Placement details

Details given in the Annexure 2

(i) Relevance of UG and PG programmes to recruiters, potential and on-campus recruiters.

- A comprehensive survey of the potential employers yet to be undertaken.However, on successful completion of M.Tech programme, our students findemployment with PSUs, NGOs, R&D organizations, Academic Institutes, and private sector companies.

(j) Benchmarking of curriculum.

Details given in the Annexure -3.

2. Teaching environment

2.1 Student-Teacher ratio separately and total for UG, PG, PhD (based *on gross numbers and on class size basis*)

Student- Teacher Ratio					
Programme	**2009-2010**	**2010-2011**	**2011-2012**	**2012-2013**	**2013-2014**
Total No. of faculty	22	22	20	18	17
M.Tech	5.68	7.4	7.35	7.8	8
PhD	4.64	4.13	4.75	6.11	6.8

2.2 No. of students graduated in each programme, incl. PhD, (*data for 5 yrs*)

S. No.	**Year**	**M.Tech. (Energy Studies)**	**M.Tech. (Energy & Environment Management)**	**Ph.D.**
1	2009	22	17	17
2	2010	18	18	13
3	2011	22	22	19
4	2012	26	31	27
5	2013	25	38	19

2.3 Student-T.A. (or student-hours/T.A.) ratio

(a) M. Tech.

Year	Total Number of Students	Number of students with Assistantship	Student-T.A. ratio
2009-2010	125	34	0.272
2010-2011	163	44	0.269
2011-2012	147	50	0.340
2012-2013	141	51	0.362
2013-2014	136	43	0.316

(b) Ph. D.

2.4 No. of skilled technical staff : 10

Year	Total Number of Students	Number of students with Assistantship	Student-T.A. ratio
2009-2010	102	31	0.30
2010-2011	91	20	0.22
2011-2012	95	19	0.20
2012-2013	110	29	0.26
2013-2014	116	32	0.27

2.5 Gross laboratory space; break-up of lab space for core UG / PG teaching

Name of the Laboratory	Room No.	Total Area (Sq. ft)
Wind & Hydro Energy System	V/WS-107 & V/WS-104	1152
Plasma I	MS-514	680
Fuel Biotech Environmental	V/WS-101 V/WS-102 V/177	529

Engine & Unconventional Fuels	V/135 & V/136	1650
Plasma Processing	V/WS-106	504
Plasma & Environment	V/236	651
Photovoltaic	V/349 & V/350	979
Surface Plamonics	V/335	890
Plasma Simulation	V/WS-202 V/WS-201	274
Energy System Simulation	V/WS/211	256
Thermal Device Testing	V/WS-105	288
Solar Concentrator	V/WS-208	576
Environmental Biotechnology	V/402	653
Gas Chromatographic	V/WS-209	173
Photovoltaic Thermal	V/334	207
Solar Distillation	V/333	294
Energy & Environment	V/151	750
Plasma Physics	V/139	540
Information Technology	V/412 B	352
M.Tech Lab.	V/412 & V/412 A	704

2.6 Laboratory modernization performed in last 5 years for (i) UG core, (ii) PG core, (iii) elective courses (*attach data before and after modernization),*

Infrastructural facilities developed in M.Tech lab for Fuel Tech lab: Bomb calorimeter, C, H, N, S analyser.

Infrastructural facilities and operational structure has been modernized for solar photovoltaic laboratory.

2.7 Course files for each course for last 5 years

The faculty is being requested to work towards systematic preparation of course files for courses
being offered by them from time to time. It would, however, take some time to consolidate the
same and make them presentable.

2.8 Study materials (monographs, notes, books, videos, web-based materials, etc.) prepared, course-wise,

Prepared, used and maintained by individual faculty. In future, it is envisaged to make them available on a consolidated basis.

2.9 Research and Innovations in teaching-learning processes

1. Started offering five bridge courses as "compulsory 'Audit' courses", for M.Tech (Evening) programme on Energy and Environment Management in view of heterogeneous academic and professional background of the students.
2. Several outdoor experiments offered to provide hands on skill training for ESL 740, ESL 340 ESL 713 and ESP 700.

2.10 No. of students (UG and PG separately) who have spent at least a semester at another university/institute (overseas or Indian).

10 M.Tech. Students (on and average two students per year visit universities in Germany under DAAD exchange programme).

2.11 No. of students from overseas universities who have taken classes, done project work or internship, UG & PG separately, in the department.

Programme	**Number per year**	**Remarks**
UG/PG courses	4	Usually exchange students
M.Tech Project	1	Occasionally, exchange student
Ph.D	1	Continuing

2.12 Course feedback.

In general very good. For two of our courses (ESL 760, ESL 340) during academic session 2012-2013, the associated teaching faculty were given excellence- in- teaching award.

2.13 Industry experts who have delivered lecture(s), seminars, discussions as part of a core/elective course – UG and PG separately.

Mr. Gulshan Kapoor, CEO, Advance Electronic Systems, in ESL 755 (Solar photovoltaic devices and systems).

2.14 Industry exposure to students – course-related visits to factories, sites, industry exhibitions, field trips, etc. – UG and PG separately.

Visit to TERI Gram, Gwal Pahari Feb. 2013, Visit to Thermal Power Plant , NTPC, Jhajjar, Oct.2013.

3. Research

3.1 No. of Master's and Ph.D. students supported - (i) by Institute Assistantship, (ii) on sponsored projects/consultancies, (iii) others sources and (iv) sponsored by external organizations.

Ph.D.

Year	Institute Assistantship	CSIR	QIP	Project	MNRE	Inspire	UGC	FOA	PT	Total
2009-2010	31	4	6	3			2		56	102
2010-2011	20	3	6				1	1	60	91
2011-2012	19	3	8	2	1		1	1	60	95
2012-2013	29	9	10	6	3	3	4	2	44	110
2013-2014	32	7	11	2	6	3	7	3	45	116

Note: Approximately 47% of the total full time PhD students are supported by external funding.

M.Tech : JES

Year	Institute Assistantship	Others (NTPC/QIP/Self sponsored)	M.Tech (Evening) working professional	Total
2009-2010	34	9	82	125
2010-2011	44	12	107	163
2011-2012	50	5	92	147
2012-2013	51	9	81	141
2013-2014	43	10	83	136

3.2 No. of Ph.D.s enrolled, graduated per faculty for last 5 years (Please check consistency with numbers given in previous table!!)

S. No.	**Year**	**Student Enrolled**	**Student Graduated**	**Total Faculty**	**Student Enrolled Per Faculty**	**Student Graduated Per Faculty**
1	2009-2010	102	17	22	4.73	0.77
2	2010-2011	91	13	22	4.13	0.59
3	2011-2012	95	19	20	4.75	0.95
4	2012-2013	110	27	18	6.1	1.5
5	2013-2014	116	19	17	6.80	1.12

3.3 Areas of research (e.g. areas listed in Prospectus, and others) by (i) Volume (quantifiable parameters), (ii) Breadth, and (iii) Years these have been research areas (Details of areas of research are given in point 1.1 (b) and 3.12.

3.4 Publications per faculty (average per year for last five years) in academic journals.

Average publication per faculty per year= 4

List of publications attached in Annexure 4.

3.5 Publications (journal and conference) total and per (a) Ph.D. student, (b) Masters student.
Per Ph. D. student = 4.
Details attached in Annexure 4.

3.6 Best papers in last 5 years: (i) Individual best 3, (ii) department/centre best 10; and brief justifications.
Centre best 10 papers

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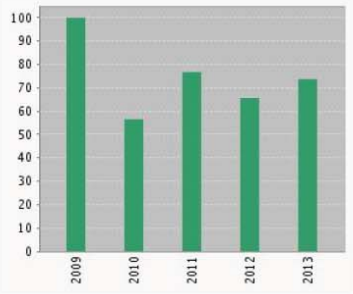

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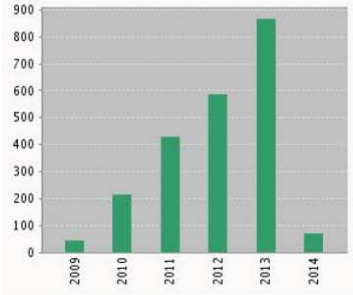

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	2010 ◄	2011	2012	2013	2014 ►	Total	Average Citations per Year
	215	431	589	867	74	2221	370.17
1. **Role of renewable energy sources in environmental protection: A review** By: Panwar, N. L.; Kaushik, S. C.; Kothari, Surendra RENEWABLE & SUSTAINABLE ENERGY REVIEWS Volume: 15 Issue: 3 Pages: 1513-1524 Published: APR 2011	0	2	27	41	6	76	19.00
2. **A review on electrochemical double-layer capacitors** By: Sharma, Pawan; Bhatti, T. S. ENERGY CONVERSION AND MANAGEMENT Volume: 51 Issue: 12 Pages: 2901-2912 Published: DEC 2010	0	8	20	36	5	69	13.80
3. **Combustion analysis of Jatropha, Karanja and Polanga based biodiesel as fuel in a diesel engine** By: Sahoo, P. K.; Das, L. M. FUEL Volume: 88 Issue: 6 Pages: 994-999 Published: JUN 2009	12	17	12	16	3	64	10.67
4. **Development of phase change materials based microencapsulated technology for buildings: A review** By: Tyagi, V. V.; Kaushik, S. C.; Tyagi, S. K.; et al. RENEWABLE & SUSTAINABLE ENERGY REVIEWS Volume: 15 Issue: 2 Pages: 1373-1391 Published: FEB 2011	0	6	21	26	4	57	14.25
5. **Process optimization for biodiesel production from Jatropha, Karanja and Polanga oils**	9	10	17	14	1	52	8.67

	By: Sahoo, P. K.; Das, L. M. FUEL Volume: 88 Issue: 9 Pages: 1588-1594 Published: SEP 2009							
6.	**Comparative evaluation of performance and emission characteristics of jatropha, karanja and polanga based biodiesel as fuel in a tractor engine** By: Sahoo, P. K.; Das, L. M.; Babu, M. K. G.; et al. FUEL Volume: 88 Issue: 9 Pages: 1698-1707 Published: SEP 2009	2	10	9	22	0	44	7.33
7.	**Analytical expression for electrical efficiency of PV/T hybrid air collector** By: Dubey, Swapnil; Sandhu, G. S.; Tiwari, G. N. APPLIED ENERGY Volume: 86 Issue: 5 Pages: 697-705 Published: MAY 2009	11	7	11	7	0	41	6.83
8.	**Bioleaching of heavy metals from sewage sludge: A review** By: Pathak, Ashish; Dastidar, M. G.; Sreekrishnan, T. R. JOURNAL OF ENVIRONMENTAL MANAGEMENT Volume: 90 Issue: 8 Pages: 2343-2353 Published: JUN 2009	8	7	12	11	1	40	6.67
9.	**Performance evaluation of a hybrid photovoltaic thermal (PV/T) (glass-to-glass) system** By: Joshi, A. S.; Tiwari, A.; Tiwari, G. N.; et al. INTERNATIONAL JOURNAL OF THERMAL SCIENCES Volume: 48 Issue: 1 Pages: 154-164 Published: JAN 2009	9	11	11	6	0	38	6.33
10.	**Long-term storage stability of biodiesel produced from Karanja oil** By: Das, L. M.; Bora, Dilip Kumar; Pradhan, Subhalaxmi; et al. FUEL Volume: 88 Issue: 11 Pages: 2315-2318 Published: NOV 2009	3	11	9	12	2	37	6.17

3.7 Average citation per department/center.

Average Citation per article = 5.94

3.8 Changes, modifications, etc. done to improve the quality of (i) M.Tech., and (ii) Ph.D. graduates.

The entire course curricula of both M.Tech programmes offered by the centre was revised and
updated based on a workshop held in July, 2009. Moreover, new courses have been floated from
time to time.

3.9 Sponsored projects - (i) individually, (ii) with another faculty of the group/section of the department, (iii) with another faculty of the department but from another group/section of the department (iv) with another faculty of another dept/center.

The list of projects is attached in Annexure 5 (Part 1).

3.10 Industry consultancies

The list of consultancies is attached in Annexure 5 (Part 2).

3.11 New areas of research which are different from the faculty's PhD thesis area.

Alternative fuels, hydrogen energy, industrial waste and effluent treatment, solar energy utilization, energy economics and planning, energy efficiency and conservation and management, solar refrigeration, air conditioning, solar architecture, environmental pollution, carbon material, polymer, PV hybrid system, green house technology, integrated rural energy technology.

3.12 Methodology for (i) identifying obsolescence in research areas, and (ii) identification of new areas for future research.

The faculty of the centre, at periodic intervals, assesses the utility of each of the prominent research interests of the faculty (existing as well as new ideas) from the viewpoint of their relevance for various stakeholders.

3.13 Number of large interdisciplinary projects (within department's areas, and across the institute).

Three

4. Innovation, Design and Development

4.1 No. of students who have been funded for innovating (TePP, PRISM, etc.).

None

4.2 Technology developed (*give list and brief information*).

S. No	Technology/ Product	Details
1	Technology developed on Organo-refining of coal:	This technology was originally developed through the research work on the organo-refining of coals through solvolytic extraction in the laboratory. As the Tata Steel Ltd., Jamshedpur had shown a great interest in this technology therefore this technology was further developed through consultancy projects from the Tata Steel Ltd. Jamshedpur and based on this several international and national patents have been filed. This technology has been transferred to the Tata Steel Ltd., Jamshedpur and a pilot plant based on this technology has already been set up by the Tata Steel Ltd., in the Kolkata. Some other technologies had been transferred to industries earlier.
2	Development of large volume with compact ECR base plasma source.	The most important contribution of the Experimental Plasma Group has been to build the Plasma Physics Lab (PPL) at IIT Delhi as a joint activity of CES and the Physics Department from its very inception and consolidating it to its present level, with a goal of catering to the requirements of the national fusion energy program. Today PPL specializes in different types of Plasma Sources like the ECR, microwave, helicon, large-volume plasma sources. A high point in the lab's achievements is the work done on large volume ECR plasmas for which two patents were filed. Relevant experts at the Institute for Plasma Research (IPR) have found the work carried out in PPL on large volume ECR based plasma sources to be of great interest. It has been identified to have the potential of becoming (after some further development) the workhorse of positive or negative ion sources which are needed for generation of high current, high energy neutral beams used in auxiliary heating and diagnostics of fusion grade plasmas. This

		technology development at PPL is unique and after careful nurturing (at IIT Delhi and at IPR) can form the basis of a unique technology contribution from India to the world fusion program. IPR is therefore very keen to set up a collaborative program with IIT Delhi, which could initially concentrate on the development of ECRH based ion sources for neutral beam systems with a budget ~ INR 10 crores for the coming 6 years. It is being planned to carry out this work under a broad-framework MOU between IPR and IIT Delhi.
3	Development of multi-cylinder hydrogen engine	Development of multi-cylinder hydrogen fuelled Spark Ignition engine for Mahindra & Mahindra Three wheeler and Minibus (undergoing).
4	Dual Fuel technology for utilization of gaseous fuels in diesel engines	Dual Fuel technology developed for utilization of gaseous fuels (CNG and Hydrogen) in Diesel engines.

4.3 **Technologies transferred**

S. No	**Technology**	**Transferred**	**Remarks**
1	Technology for organo-refining of coals through solvolytic extraction	Tata Steel Ltd. Jamshedpur.	
2	Biodiesel utilization in multi-cylinder engine	GM Tavera vehicle	
3	Hydrogen fuelled three wheelers (DELHY 3W) (15 Nos.)	Mahindra & Mahindra	undergoing field trials

4.4 Number of patent filed

S. No	Description	Status
1	An improved process for the preparation of demineralised Coal having low ash.	Indian **Granted** Patent # 197340 253307

2	Organo-refining process to produce low ash (<4%) clean coal with maximum possible yield	Indian **Granted** Patent # 229474
3	A process to produce low ash clean coal from high ash coals for various metallurgical applications	Indian Filled on 06/08/07 Application No. 1088/KOL/07
4	An innovative process to produce low ash clean coal from high ash coals for various metallurgical applications	Indian **Granted** Patent # 253307
5	A process flow sheet for pre-treatment of high ash coal to produce low ash clean coal	International (PCT) Filed on 19/01/2012
6	Hydro treating catalyst, process for preparing the same and use thereof.	Indian Filed on 7/09/2012 Application No.- 2603/MUM/2012
7	Hydro treating catalyst, process for preparing the same and use thereof.	International (PCT) Filed on 19/01/2012
8	Process of preparing catalyst from biomass and its use thereof	Indian Initiated Filing
9	Permanent Magnet Compact Electron Cyclotron Resonance Plasma Generator	Indian Filled on Jan 6, 2006 Application No. 66/DEL/2006
10	Systems for Production of Large Volume High Density Plasmas for Industrial Applications Using Compact ECR Plasma Sources,	Indian Filled on April 13, 2006 Application NO. 992/DEL/2006
11	Control Strategy of Optimum CNG Fuel Injection for BSEC Improvement and Emission (CO_2 and NO_x) Reduction of a Dual Fuel Stationary Diesel Engine, and	Indian
12	Crude Glycerol biodiesel production as a processing aid for industrial explosives	Indian
13	Synthesis of Gold and Silver Nanocrystalline films using Spray Pyrolysis Technique	Indian Filled on 25/11/2011

14	A Method for the Synthesis of Mercury cadmium Telluride Nanoparticles.	Indian Filled on 25/11/2011 Application No. 086/DEL/2005
15	Design of Externally Controlled Spray Pyrolytic Nanoparticle Fabrication System	Indian **granted** Filled on 24/01/2010 Application No. 2712/DEL/2009
16	Process for Making Nanorods of Zinc Oxide and Resulting Products Thereof	Indian **granted** Filled on 13/09/2010 Application No. 2163/DEL/2010
17	System for Organic Devices Fabrication under Ocygen Free Ambience	Indian Filled on 20/12/2013 Application No. 3724/DEL/2013
18	Vertical Axis Wind Turbine	Indian In process

4.5 Innovation of products, processes, designs etc. in the Centre

S. No	**Name**	**Details**
1	Test procedure for Box Type Solar Cooker	Led to the development of the Indian (BIS) standard on Box Type Solar Cooker
2	Test procedure for parboiled concentrator solar cooker r	Led to the development of a unified test procedure being used by Regional Test Centers of MNRE
3	Vertical axis wind turbine,	Wind turbine that can operate at low wind speeds and modular in construction with possibility of mechanical coupling

4.6 Availability and access to students' workshops, "tinkering laboratories" so that they may pursue their own ideas.

All M. Tech. and doctoral students are encouraged to interact with faculty and laboratory staff to pursue their own ideas using the facilities available with the laboratories of the Centre.

4.7 No. of students/teams who have competed in national / international competitions, and outcome.

None

5. R & D Environment

5.1 No. of post-doctoral scholars hired in the department/centre and their durations, from (i) abroad, (ii) on project, and (iii) others, and outcomes.

Number of post-doctoral scholars hired only in the projects – 9
They also have been involved in the research and mentoring of Ph. D. students

5.2 No. of foreign students enrolled in (i) Masters, and (ii) PhD programmes.

1 Ph. D. student (from Japan) enrolled in the last five years.

5.3 No. of Indian and foreign faculty/researchers that have spent a sabbatical in the department.

None

5.4 Sabbatical taken by faculty and where spent.

S. No	Name	Institution	Duration
1	Prof D.K.Sharma	Max Planck Institute Germany	6/1/2011 to 31/12/2011
2	Prof T.C.Kandpal	Dalarna University Sweden & Technical University of Kaiserslautern, Germany	6/8/2011 to 31/10/2011 & 1/11/2011 to 31/03/2012

5.5 **Number of seminars (education and research separately) given by the faculty (i) in the department**, (ii) in other departments, (iii) at other institutions.

S.No.	**Seminars**	**Total Number between 2009-2013 by all the faculty members**
1	Inside Centre	15
2	In other Dept.	0
3.	Other Institutions	200

5.6 No. of faculty/researchers/scholars invited by the department for giving (i) seminars, (ii) spending at least a week in the department.

Seminars: 18

5.7 Adequacy of research infrastructure.

S. No	**Area**	**Existing Infrastructure/Facility**
1	Renewable Energy Technology	o Photovoltaic Module and System Test Facility Including PV Pump, Solar Lanterns, Inverters for PV system. o Indoor/Outdoor Test Facility for Solar Distillation

		Systems. o Thermal Conductivity Analyser. o U Value Measurements. o Alphatometer and Emissometer. o Solar Cooker Test Set Up. o Thin Film Deposition Facility. o 25 kWp PV solar roof (for stand alone and grid interactive application) o Spray Deposition Facility o Capacitance Measurements of solar cells o Spin Coater for Organic –Inorganic semiconductor layer deposition o 68HC11 based embedded system design o Thin Film Deposition System for making Metal Contacts.
2	Energy Efficiency	o Indoor Comfort Meter o Low Pressure Biogas Burner Testing Facility o Rodex Potentiometer o High Rate (upto 500 kW) Oil Burner, Combustion Chamber, Channel and Exhaust System. o Evaluation of Biomass Fuel Stores for Thermal Efficiency and Air Pollution Emissions o A collection of softwares backed by the relevant data base is available in CES. The software packages can be used for Energy Efficient Building Design, Solar Photovoltaic and Solar Thermal System Design, Hybrid System Design and Calculation of AC loads. Optimal Power System Expansion Model including the Environmental Impacts and Design and Analysis of Electrostatic Precipitator.
3	Fuel Technology	o Gas Chromatograph : Gas Analyser o Muffle Furnace : Proximate Analysis of Fuels o Coke Reactivity Index o BOD Incubator with Rotary Shaker o Sox let Extractor o Bomb Calorimeter o Pyrolyser o Microbial activities related to Coal, Biomass and industrial effluents o Fractionation of Liquid Mixtures
4	Internal Combustion	o Facility for Basic Testing of Engine (Performance and Emission Characteristic).

	Engines and Alternate Fuels	o Dynamometer for Evaluation Engine Performance. o Gas Analysers for Measuring CO, HC and NOx Emission. Cylinder Gas Pressure Measurement and Processing Unit. AVL Research Engine with Facility to vary Compression Ratio, Ignition/Injection Timing. o Passenger Car Engine Test Bed. o Engine Data acquisition System. o Smoke Meters (AVL smoke meter). o AVL Visio FEM Analyser for Measurement of Flame Kernel Growth Rate. o Gas Chromatograph. o Karl Fischer Coulometer for Measuring Oxidation Stability. o Rencimate for Measuring Moisture Content. o Bio-Diesel Production Unit (50 l/batch). o Other Facility (Flash, Pour and Cloud Point Measuring Apparatus). o Software's- o AVL Fire for Analysis of 3-Dimensional Fluid Dynamic Model of I.C. Engines. o AVL Boost for 1-Dimensional Thermodynamic Modeling of I.C. Engines.
5	Plasmas Science & Technology	o Plasma Deposition of Thin Films. o Dielectric Barrier Discharge for Fuel Gas Cleaning. o Negative Ion Generating System. o High Speed Coating and Surface Treatment using Thermal Plasma. o Broadband Power Amplifiers in RF & LF Ranges upto to a few Hundred Watts. o Spectroscopic System for (a) Measuring Flame Temperature up to 3000 K (b) Spectrum Analysis of Light Sources in Visible Range. o Microwave Generator at 2.45 GHz upto 5 kW Power o Software on beam propagation methods and self organization/chaos. o High Speed Computing Workstation Clusters
6	Electrical Energy Systems	o Electronic Circuit Design & Testing. o Real Time Monitoring of Micro Alternator. o Vertical Axis Wind Turbine Power Generation

		o Micro-Hydro Power Generation

5.8 Adequacy of technical staff – existing numbers and competency areas; competency areas in which there is a shortage.

S. No	Designation	Existing No	Competency area in which there is a shortage.
1	Senior Technical Supdt.	4	System administrator is needed for computational interface management
2	Technical Superintendent	1	The plasma physics laboratory (PPL) of the centre requires expertise and maintenance in areas like vacuum, high power microwaves/rf, high voltage equipment, etc. At present only one technical staff is available and it would be very helpful if two more staff could be recruited for smooth running of the lab.
3	Jr. Technical Superintendent	4	Two engineering background staff needed for M. Tech. laboratory
4	Senior Mechanic	1	

5.9 Work space available for (a) Masters students, (b) Ph.D. students, (c) project staff, (d) Post doctoral scholars.

5.10 Work space available for

S. No	Student category	Space Allocated (on an average basis)	Remarks
1	M.Tech	20 sq. ft.	
2	Ph.D	100 sq. ft.	Most of the doctoral students and project staff are accommodated in the corresponding laboratories, M.Tech. students doing project work are also using the
3	Project Research Staff	--	

			laboratory space.

- Some of the research labs including Plasma, solar photovoltaics, and IC engine are barely managing within the space available.

5.10 No. of national conference/workshops/seminars attended by PhD students (*total and per student for 5 years*).

- Per student : 2 per year

5.11 No. of international overseas conference/workshops/seminars attended by PhD students (*total and per student for 5 years*).

- Per student: 0.5 per year

5.12 No. of students who have continued to Ph.D. (i) in same dept., (ii) other departments of IITD, (iii) in India, and (iv) abroad (separately for M.Tech. and B.Tech. students).

- Almost 20% of the research students joining the doctoral programme of the Centre are M. Tech students of IIT Delhi.

5.13 No. of projects with co-guide from industry

- 5 students

5.14 No. of students who have spent time in industry as part of thesis/project work (give number and duration).

- More than 10 Ph. D. students

(i) 3 students are in constant touch with BHEL and Central Electronics Ltd. for silicon solar cells related work.

(ii) Sponsored M.Tech students doing project relevant to industry, with mentor CES, IIT Delhi

5.15 Self assessment reports of the department/centers/schools if any.

- Individual faculty submits the self-appraisal report annually to the administration.

5.16 Placement of M.Tech. and PhD graduates in technical careers (*as per format at Annexure-5*).

- On-campus **placement** for Master's student is about **50**% for the last two years.

- The Ph.D students are employed as faculty in academic institutions, research organizations, industry and NGOs etc.

5.17 Inter-disciplinary work -: (i) joint thesis guidance by faculty across groups within a department, or across departments/centres, (ii) Proposals submitted and funded – PI-CoPI and their group/department affiliations.

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6. Outreach / External stakeholder engagement

6.1 Educational

(a) Workshops/Short term courses – topical research for disseminating research of IITD.

- 43 Workhops/ short term courses are conducted by the CES faculty in last 5 years

(b) Workshops/Short term courses – educational methods (teaching, learning resources, pedagogy).

Educational outreach has been in the form of short term courses and training programmes organized under the aegis of CEP, QIP, and FITT. Several of the

short term courses offered by the Centre are on self-sponsorship basis and yet have reasonably large audience from industry, NGOs, academia and other stakeholders. In addition to this, the faculty delivers invited talks in various academic and research institutions as well as in the industry. Also the faculty is involved in the activities of Science Day and Open House . The number of **books** authored by the faculty with sale of more than 1000 units is 3. The faculty of the Centre represents the Institute in a large number of government (MNRE, DST, BIS, etc.) and other committees. The faculty of the Centre has been regularly interacting with foreign institutions and laboratories in terms of delivery of guest lectures, exchange of knowhow and other relevant activities.

(c) Learning, research material on the website.

-

(d) Science & technology for public information – on website.

-

(e) Courses taught to students of other IITs/NITs/Other institutions.

None

(f) Courses taught via NKN.

- None

(g) Courses developed for NPTEL.

- None

(h) Books, monographs, study material made available outside IITD.

- Total Books, Monographs and Manuals from CES: About 50

(i) Experiments developed and made available to other institutions.

- 5

(j) Seminars live/via NKN, web to other institutions in India/abroad

- None

(k) Reach out to schools, NCERT, KVs, etc. (e.g. K-12 programmes).

- Lectures delivered in INSPIRE on Renewable energy.
- Participated in National Science Talent Search activity of NCERT
- On Science Day lecture delivered for K-12 students and engineering students in engineering institutions in NCR.

(l) Mentoring of other institutions, e.g. new IITs, NITs, universities, etc. including faculty mentoring, curriculum development, laboratory development, etc.

- First IIT to start Master of Technology level courses in Energy/Renewable Energy study. The faculty expertise has been used by most of the other institutions in the country initiating academic programmes in this area.
- Involved in mentoring research activities in several universities/institutions in the country and abroad

6.2 Industry collaboration

(a) No. of students (Ph.D./Masters) directly linked to industry funded projects.

- Five students

(b) No. of industry staff/engineers who have taken a regular course(s) for entire semester.

None

(c) Technology transfer to companies, entrepreneurs, local and other governments/government agencies, NGOs (separately).

- Biodiesel utilization in multi-cylinder GM Tavera vehicle.

- Hydrogen fuelled three wheelers (DELHY 3W) (15 Nos.) developed undergoing field trials at PragatiMaidan, New Delhi

(d) Continuing education/courses for industry.

- Regular QIP programmes – on an average 3 per year.
- Programmes under the aegis of FITT: 2 per year

(e) Faculty secondment to industry.

- None

(f) Research projects undertaken with industry as partner.

- Three: with (i) Mahindra & Mahindra, and Kirlosker Oil India Ltd.) (ii) IOCL and (iii) with BHEL

(g) Laboratories, equipment, etc. provided by industry for use in UG / PG teaching laboratories and student projects.

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(h) Seminars/workshops held with industry by the department.

- One day Work Shop held on Hydrogen Safety by Air Products,USA.

- One day joint programme for Industry and Institution interaction on Biogas utilization in Vehicle

6.3 Professional

(a) Service as Board, Senate, selection committee member at other IITs, NITs, and Universities.

- Some of the faculty are/have been members of such committee

(b) Service as Ph.D. thesis examiner at other institutions.

- External Examiner for Ph.D/M.Tech./M.S. Thesis evaluation for other Universities including IITs and NITs.

- About 50 Ph. D. theses examined in last five years.

(c) Service as technical expert on committees – MHRD, DST, DSIR, DRDO, Pan-IIT initiatives, other ministries, state and local governments.

- Many of the CES faculty is contributing as members of a large number of committees of these and several other organizations.

(d) Technical expert on policy, regulatory, laws, standards committees.

- Expert Committee Member for preparing Draft Auto Fuel Vision Policy 2025
- Members, Bureau of Indian Standards committees

(e) Member of Board/Advisory Board of public and private sector corporations.
-

(f) Positions (e.g. Director, Vice Chancellor, etc.) held by faculty on lien.

4 - (Director/Vice-Chancellor)

6.4 Contribution to national development goals

(a) Projects undertaken and their outcome.

List of projects undertaken in last 5 years is given in Annexure- 5.

(b) Policy inputs – implications, visible impact on society.

-

(c) Entrepreneurship development.

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6.5 Alumni engagement

(a) Regular interactions / engagement with alumni and outcomes.

- The Centre attempts and encourages to continue interacting with its alumni within existing constraints.

(b) Contributions from alumni.

-

6.6 Recognitions and Awards

(a) Awards to faculty

A few International and numerous National awards are received by the CES faculty like; International Association of Hydrogen Energy, Solar Energy Society of India and UNESO/ROSTSCA young scientist awards, "Rajiv Gandhi Samman", Lockheed Martin DST “India Innovators Award.

(b) Fellows of academies, INAE, etc.

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7. Governance

All the decisions (regarding allocation of physical and financial resources, delegation of responsibilities, activities pertaining to departmental management and operations, faculty searches, and selection of students for different academic programmes) in the Centre are made through Faculty Board / Centre's Research Committee / Professorial Committee as applicable.

7.1 Governance

(a) Organization structure – their autonomy/ terms of reference

(b) Planning documents developed by the department – space, faculty, staff related.

(c) Records of discussions within the department – internal documents (meeting minutes, position papers, discussion papers, concept papers, etc.)

(d) Physical resources – percentage utilization for UG PG core and electives teaching separately, UG and PG student projects, Ph.D. student research. Projections for future.

(e) Financial resources – (i) funds provided to the department, (ii) processes of distribution, (iii) funding for focus areas, (iv) funding for UG and PG core teaching laboratories. Outcomes of funds utilization. Changes in funding pattern and funds utilization, and effects on departmental strategy.

(f) Delegation of decision making within department/centre. List the processes and structures for financial and academic management, and the methodology for their review.

7.2 Department management and operations

(a) Organization structure - mandates, flexibility, etc.

(b) Processes for curriculum planning.

(c) Processes and methods for teaching resources management.

(d) Guest faculty, affiliation for teaching core, elective UG & PG courses.

(e) Faculty short-listing criteria.

(f) How collectiveness of the faculty has enhanced academic output and enhanced quality, etc.

(g) Nature, quantum and quality of support from of secretarial staff, stores and inventory management, purchases, ambience, etc.

7.3 Faculty

(a) Faculty profile, and a critique of the same.

(b) Diversity in faculty profile by: (i) gender, (ii)category, (iii) region, (iv) Ph.D. institution, (v) post-doctoral institutions worked in, (v) organizations/industry worked in, (vi) employment prior to joining the department.
(c) Procedure for faculty searches.
(d) Result of faculty searches – area-wise (as in Annexure IV), number of applicants, short-listed and offered a position, their educational qualifications & experience.
(e) Success in recruitment (data for last 5 years), and offers that the persons had from other IITs/IISc/TIFR.
(f) Faculty lost to other institutions post selection.
(g) Faculty time utilization – in class, in meetings, project management, Ph.D. guidance, Masters project guidance, UG project guidance.
(h) Level of harmony amongst department faculty.

7.4 Students

(a) Criteria for short-listing and selecting students for admission to Master's and Ph.D. programmes of past 5 years.
(b) Facilities provided to students and their maintenance/management system.
(c) Mentoring seminars/sessions held for Ph.D. students for prospective faculty careers.

8. Benchmarking

8.1 Identify departments/centres within IITD as peers.
8.2 Identify departments/centres/schools/divisions from other IITs, IISc, NITs, private universities as peers, and reasons/criteria there for.
8.3 Identify departments/centres from institutions in other countries as peers.
8.4 Define parameters for benchmarking (i) research, (ii) curriculum - separately for UG, Masters, and Ph.D. programmes, (iii) teaching-learning processes.
8.5 Perform benchmarking and report the analysis/findings for the last 5 (or 10) years.

After IIT Delhi, IIT Bombay, IIT Kharagpur, Jadavpur University, Calcutta, DAVV Indore, MANIT Bhopal took initiatives to start formal academic and research programmes in the field of energy. Many other institutions in the country have later initiated academic programmes. The faculty of the Centre has been closely interacting with faculty colleagues in these institutions. Based on the readily available authentic (web based) data a brief comparison of some of the features of the Centre with the Department of Energy Science and Engineering is

presented in the following table (along with corresponding snapshots from Web of Science).

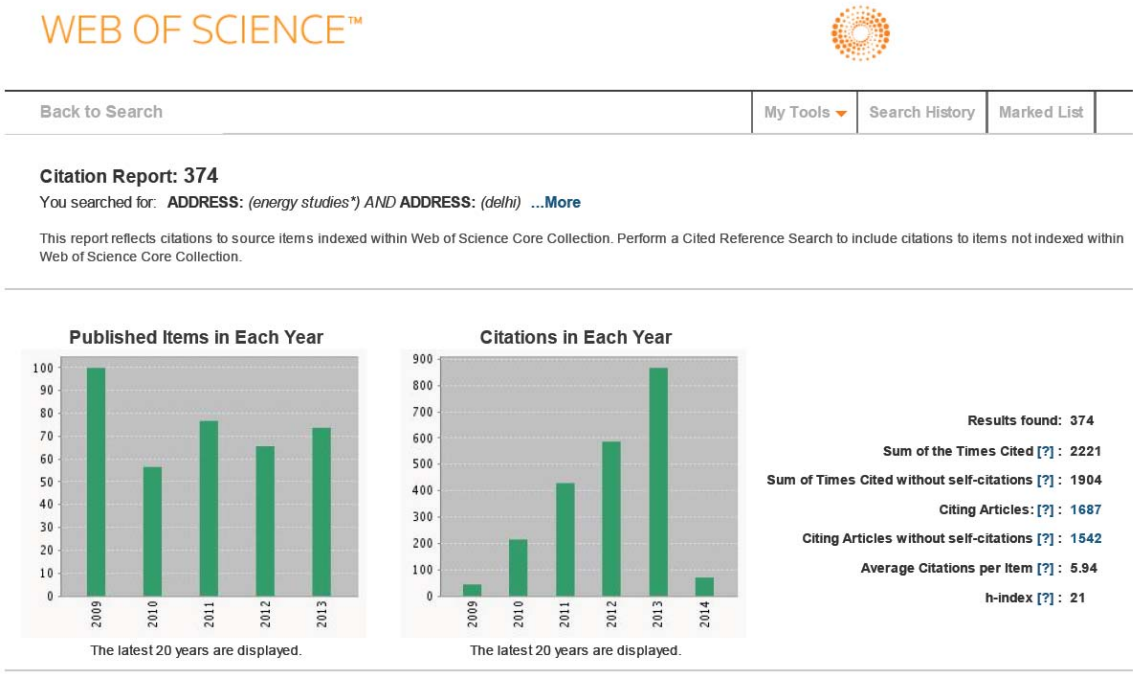
Being the first entity to start university level educational programmes (M. Tech. and Ph. D.) in the country in the area of energy and having had the privilege of contributing to the manpower requirement of most of the potential employers in the country in this area we envisage to continue with the activity with renewed vigour and focus. The activities envisaged in this regard include an M. Tech. Programme in Renewable Energy (The Ministry of New and Renewable Energy, Government of India has already sanctioned 15 fellowships for an M. Tech. Degree programme in Renewable Energy), offering increased number of elective courses to undergraduate students of the Institute (with the primary objective of introducing the potential and challenges of harnessing renewable energy sources and associated environmental consequences to the undergraduate students), and to offer a B. Tech. programme in Energy Engineering (with special emphasis on energy efficiency and renewable energy utilization). Functional interaction for student exchange would be established with other institutions (in the country and abroad) imparting energy education and training. The Centre would undertake research and development activities in the areas as outlined in the main document for review.

Comparison of CES IIT Delhi and Dept.. of Energy Science and Engineering IIT Bombay

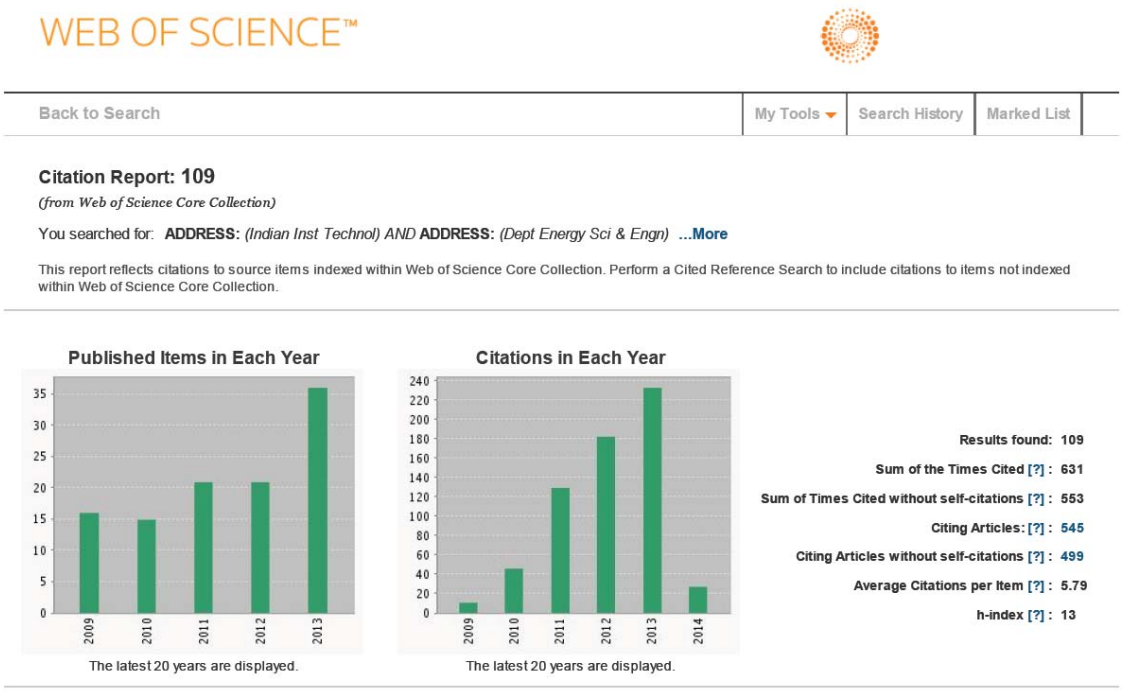
S. No	Indicators In last 5 years 2009-2013	IIT Delhi Centre for Energy Studies	IIT Bombay Dept. of Energy Science & Engg.
1	Present Faculty Strength	17	18
2	Publications	374	109
3	Total citations	2221	631
4	Publications	22	6

	per faculty		
5	h- index	21	13

IIT Delhi, Centre for Energy Studies



IIT Bombay, Dept. of Energy Sci.ene & Engg.



9. Feedback systems and results

9.1 System for feedback from UG students and its results.

- Not Applicable

9.2 System for feedback from PG, Master's and Ph.D., students, and their outcome.

- Feedbacks from students for all courses are collected through an online feedback survey system wherein the students are asked to answer an elaborative questionnaire (objective and subjective) about the Course Organization & Delivery, Attendence/Evaluation Policy, Practicals, Tutorials etc. Faculties are rated based on this feedback from students. Students are free to express their view on course coordinator and teaching styles. The feedback ratings are compiled/analyzed and teaching excellence awards are presented based on this to encourage/improve teaching. A sample feedback questionnaire is given in Annexure- 6.

9.3 System for feedback from recruiters (i) on-campus, and (b) off-campus - separately for UG and PG graduates; and the results.

- Training & Placement cell collects feedback from recruiters on and off-campus and provides these feedbacks for the formulation/modification of curriculum.

9.4 Mechanism of obtaining industry feedback and the findings.

- Training & Placement cell collects feedback from industries.

9.5 Alumni feedback mechanism and its outcome.

- The Centre attempts and encourages to continue interacting with its alumni within existing constraints.

9.6 Placement records – Ph.D., M.Tech. and B.Tech.

- A summary of year-wise placements of M.Tech. Students are given in annexure-2.

10. Vision for next 5-10 years

10.1 Goals and benchmarking for future in relation to (i) curricula, (ii) research, (iii) outreach, and (iv) processes for regular internal assessment.

10.2 Vision of curricula and teaching-learning processes - UG, PG and Ph.D.; innovations proposed.

10.3 Areas identified for improvement in (i) curriculum, (ii) teaching-learning processes.

10.4 New areas for research and Masters programme, and industry participation in these.

10.5 Projections for (i) funded projects, (ii) journal publications.

10.6 Projected graduation numbers - Ph.D., M.Tech. and B.Tech.

10.7 Projected faculty profile, and areas for recruitment of faculty.

10.8 Projections for future benchmarking (for comparison after 5 years) – institutions in India and abroad, and parameters for future comparison.

10.9 Infrastructure and governance - limiting factors that affect achievement of benchmarks and methods to overcome these.

10.10 Working with other departments/centers and institutions in teaching and research.

10.11 New initiatives that the department/centre will undertake.

10.12 Outreach goals and anticipated limitations in the attainment of these.

10.13 Mechanisms for effective changes based on feedback received and development and implementation of corrective measures.

10.14 Questions to which the department seeks answers from the Review Committee.

Recently prepared vision document 2013-2023 of the CES is attached with this report as Annexure 7

11. Information in public domain

11.1 Minutes of all meetings.

- Archives available in the faculty file for faculty to refer.

11.2 All reports archived in the central/department/centre libraries.

- Centre-related reports are archived in the centre.

11.3 Past vision documents, review documents, Standing Review Committee documents.

- Archived and available in the centre.

11.4 Any other documents developed by the department, a group/section of the department/centre.

- Available in the centre.

11.5 Feedback documentation and action taken on the same, and its outcome.