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Nurturing Innovation in Indian Universities to Promote Renewable Energy

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Abstract: Renewable energy is an integral part of climate change solution. The main purpose of this paper is to find out the amount of renewable energy projects done in engineering colleges. This paper evaluates the mechanical engineering projects of St. Joseph's College of Engineering and Technology, Palai, to find out the maturity of the technologies and their contribution to sustainable development. Primary focus was given to renewable energy technologies. The database was collected from the college and was analyzed accordingly. Technology Readiness Levels (TRL) and Sustainable Development Goals (SDGs) were considered as the main criteria in evaluating the projects.

Keywords: *SDGs, TRL, Engineering Projects, Indian Universities, Renewable energy.*

I. INTRODUCTION

A. Technology Readiness Level Scale Assessment

Technology Readiness Assessment (TRA) is a systematic, metrics-based process that assesses the maturity level of new technologies. Technology Readiness Levels (TRLs) are a set of metrics that enable the standardized assessment of the maturity of a particular technology and the consistent comparison of the maturity between different types of technology in the context of a specific application, implementation, and operational environment [1]. Technology Readiness Level (TRL) is a framework that has been used in many variations across industries to provide a measurement of technology maturity from idea generation (basic principles) to (commercialization). TRL can also be adapted to support understanding of capabilities and resources required to develop technologies at different stages of development.

The TRL methodology was originated at NASA in 1988 by S. R. Sadin, et. al. [3]. It has been widely adopted in both the United States and Europe. The United States Department of Defense developed detailed guidance for using TRLs in the 2003, the United States Department of Energy in 2004, and the European Space Agency in 2008 [1].

Fig. 1 below represents the thermometer scale for NASA's Technology Readiness Levels.

According to the report "Technology Readiness Level: Guidance Principles for Renewable Energy technologies" published by European Commission, the following provides an overview of the common trends identified in each Technology Readiness Levels.

TRL 1: Basic principles observed

- Identification of the new concept
- Identification of the integration of the concept
- Identification of expected barriers
- Identification of applications
- Identification of materials and technologies based on theoretical fundamentals/literature data
- Preliminary evaluation of potential benefits of the concept over the existing ones.

TRL 2: Technology concept formulated

- Enhanced knowledge of technologies, materials and interfaces is acquired
- New concept is investigated and refined
- First evaluation about the feasibility is performed
- Initial numerical knowledge
- Qualitative description of interactions between technologies
- Definition of the prototyping approach and preliminary technical specifications for laboratory test.

TRL 3: Experimental proof of concept

- First laboratory scale prototype (proof-of-concept) or numerical model realized
- Testing at laboratory level of the innovative technological element (being material, sub-component, software tool), but not the whole integrated system
- Key parameters characterizing the technology (or the fuel) are identified
- Verification of the proof of concept through simulation tools and cross-validation with literature data (if applicable)

TRL 4: Technology validated in lab

- (Reduced scale) prototype developed and integrated with complementing sub-systems at laboratory level
- Validation of the new technology through enhanced numerical analysis (if applicable).
- Key Performance Indicators are measurable
- The prototype shows repeatable/stable performance (either TRL4 or TRL5, depending on the technology)

TRL 5: Technology validated in relevant environment

- Integration of components with supporting elements and auxiliaries in the (large scale) prototype
- Robustness is proven in the (simulated) relevant working environment
- The prototype shows repeatable/stable performance (either TRL4 or TRL5, depending on the technology)
- The process is reliable and the performances match the expectations (either TRL5 or TRL6, depending on the technology)
- Other relevant parameters concerning scale-up, environmental, regulatory and socio-economic issues are defined and qualitatively assessed

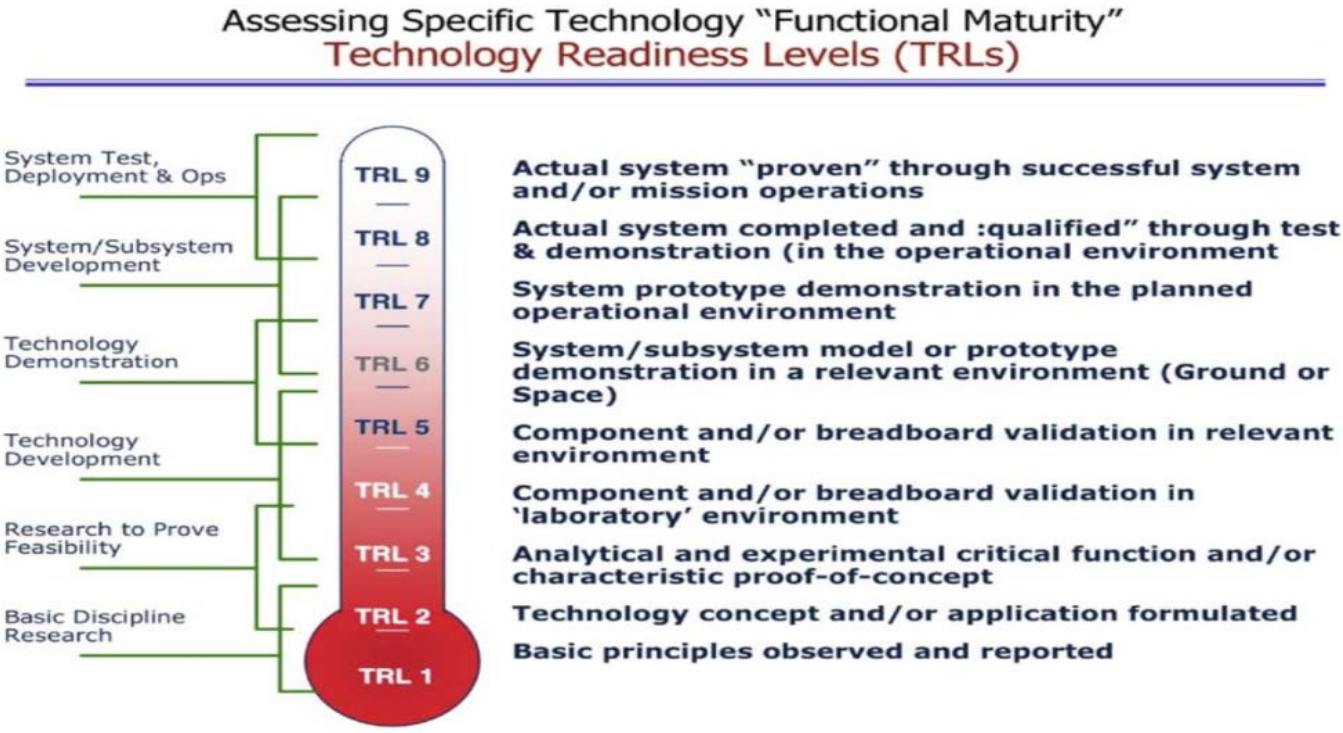

Figure 1: Technology Readiness Level

TRL 6: Technology pilot demonstrated in relevant environment

- Demonstration in relevant environment of the technology fine-tuned to a variety of operating conditions
- The process is reliable and the performances match the expectations (either TRL5 or TRL6, depending on the technology)
- Interoperability with other connected technologies is demonstrated
- Manufacturing approach is defined (either TRL6 or TRL7, depending on the technology)
- Environmental, regulatory and socio-economic issues are addressed

TRL 7: System prototype demonstration in operational environment

- (Full scale) pre-commercial system is demonstrated in operational environment.
- Compliancy with relevant environment conditions, authorization issues, local / national standards is guaranteed, at least for the demo site.
- The integration of upstream and downstream technologies has been verified and validated.
- Manufacturing approach is defined (either TRL6 or TRL7, depending on the technology).

TRL 8: System complete and qualified

- Technology experimented in deployment conditions (i.e. real world) and has proven its functioning in its final form.
- Manufacturing process is stable enough for entering a low-rate production.
- Training and maintenance documentation are completed.
- Integration at system level is completed and mature.

TRL 9: Actual system proven in operational environment

- Technology proven fully operational and ready for commercialization.
- Full production chain is in place and all materials are available.
- System optimized for full rate production.

B. Sustainable Development Goals

The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030.

The 17 SDGs are integrated—that is, they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability [6].

Goal 1. End poverty in all its forms everywhere
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3. Ensure healthy lives and promote well-being for all at all ages
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5. Achieve gender equality and empower all women and girls
Goal 6. Ensure availability and sustainable management of water and sanitation for all
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10. Reduce inequality within and among countries

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12. Ensure sustainable consumption and production patterns
Goal 13. Take urgent action to combat climate change and its impacts
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

Figure 2: Sustainable Development Goals

C. Engineering College Projects

The overall amount of money spent for student projects in a typical engineering college in Kerala would be approximately Rs. 2 million. However, only a small proportion of this amount is utilized for developing competent and relevant projects [7]. Universities and colleges are the places where innovation and new discoveries take place. Therefore, if funds are utilized more to develop mature projects that contribute to the sustainable development goals, then it would certainly have a positive impact on the economy and the environment.

D. Decentralized Renewable Energy

The application of renewable energy in post-disaster resilience is noticeable. The deployment of decentralized renewable energy is fuelling a disruptive transformation of the energy sector. The rapid growth of decentralized renewable energy technologies changes the structure of the energy sector towards a multi-actor set-up in which large utilities interact with self-producing consumers and mini-utilities [8].

E. Thrust Areas of MNRE

Moreover, the Ministry of New and Renewable Energy (MNRE), Government of India, had introduced "Thrust Areas with Action Plan for RD&D" for technology development in new and renewable energy in 2016. The objective of the program is to promote technology development and demonstration for widespread deployment of new and renewable energy for various applications in cost effective manner across the country. RD&D efforts are directed towards process/ technology development and demonstration with emphasis on cost reduction and improving efficiency. The RD&D projects are sanctioned to various R&D/academic institutions, industries etc. following the MNRE's policy and guidelines dated 18.10.2010. 169 R&D projects in solar thermal, solar PV, biogas, bio-fuel, hydrogen and fuel cells were sanctioned by MNRE in the 11th Plan Period with total budget of Rs.525 crore to various R&D/academic institutions, industries, etc., 60% of which was sanctioned for solar projects [9]. Therefore, it would be beneficial if engineering students are promoted to develop projects that come under the thrust areas introduced by the MNRE [9].

II. RESEARCH METHODOLOGY

In the present research, undergraduate engineering students' projects done by mechanical engineering students of St. Joseph's College of Engineering and Technology, Palai, Kerala were assessed based on Technology Readiness Levels and Sustainable Development Goals achieved by these projects. The details of the projects done by students from 2015 to 2019 were collected from the mechanical department. The details collected included project titles, description, date, expenditure, TRL and Sustainable Development Goals.

III. RESULTS AND DISCUSSIONS

Table 1: SJCET Mechanical Projects (2015-2019)

Sl.No	Project Title	Cost (in Rs.)	Year	Technology Readiness Level (1-9)	Sustainable Development Goal Category (1-17)
1	Hybrid Solar PV/T System	24000	2019	3	(7) Affordable and Clean Energy
2	Prosthetic Foot Movement	10000	2019	3	(3) Good Health and Well-Being, (10) Reduced Inequalities
3	Nutmeg Mace Dryer	30000	2019	4	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
4	Pedal operated reciprocating water pump	8000	2019	4	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
5	Design, fabrication and testing of microbial fuel cell	4580	2019	3	(7) Affordable and Clean Energy
6	Magneto rheological fluid braking system	15300	2019	3	(9) Industry, Innovation and Infrastructure
7	Oil skimmer with waste collecting mechanism	12450	2019	3	(12) Responsible Consumption and Production
8	Graphene reinforced delrin polymer	30811	2019	2	(9) Industry, Innovation and Infrastructure
9	Design and Fabrication of downdraft wood gasifier	14600	2019	4	(9) Industry, Innovation and Infrastructure
10	Automatic Vegetable Cutter	13920	2019	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
11	Coconut climber machine	19000	2019	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
12	Portable toilet module	17000	2019	3	(3) Good Health and Well-Being, (6) Clean Water and Sanitation
13	Fuel efficiency improvement in petrol engine using water injection	16590	2019	3	(9) Industry, Innovation and Infrastructure (12) Responsible Consumption and Production
14	Belt Trailer Truck	23000	2019	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
15	Pet bottle rope maker machine	11690	2019	3	(9) Industry, Innovation and Infrastructure (12) Responsible Consumption and Production
16	Automatic pneumatic punching machine	27000	2019	4	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
17	Structural and computational analysis of turbulent flow around NACA 4412 and NACA 4415 with ANSYS Fluent	3000	2019	2	(9) Industry, Innovation and Infrastructure
18	Design of gating and risering system for butterfly valve	3500	2019	2	(9) Industry, Innovation and Infrastructure
19	Race car active aerodynamics system	2800	2019	2	(9) Industry, Innovation and Infrastructure
20	Design and analysis of reaction wheel	3700	2019	2	(9) Industry, Innovation and Infrastructure

21	Automatic tire inflation system	18000	2019	3	(9) Industry, Innovation and Infrastructure
22	Pneumatic Brake and bumper actuation before collision	22000	2019	3	(9) Industry, Innovation and Infrastructure
23	Vortex induced vibrations for aquatic clean energy	12000	2019	4	(7)Affordable and Clean Energy, (9) Industry, Innovation and Infrastructure, (13) Climate Action
24	Fused deposition modeling using nano-materials	2000	2019	2	(9) Industry, Innovation and Infrastructure
25	Experimental Investigation on loop heat pipes using copper nano-materials	2500	2019	2	(9) Industry, Innovation and Infrastructure
26	Hybrid electrical two-wheeler	35000	2019	4	(9) Industry, Innovation and Infrastructure, (13) Climate Action
27	Automatic wall painting machine	28500	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
28	Plastic bottle recycling machine	18960	2018	3	(12) Responsible Consumption and Production
29	Airborne Wind Energy System	35,000	2018	5	(7) Affordable and Clean Energy, (9) Industry, Innovation and Infrastructure, (13) Climate Action
30	Design and fabrication of pedal water cycle	17000	2018	4	(9) Industry, Innovation and Infrastructure, (11) Sustainable Cities and Communities
31	Fabrication of machine for separating mace from nutmeg	20000	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
32	Prototype fabrication of automatic hand brake system	12000	2018	3	(3) Good Health and Well-Being, (9) Industry, Innovation and Infrastructure
33	Volume expandable fused deposition model based rapid prototyping machine	19118	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
34	Design and fabrication of mechanical mover using Klan mechanism	17000	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
35	Renewable energy generation from slow moving water	24000	2018	3	(7) Affordable and Clean Energy , (9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
36	Design and fabrication of universal wrench tool	23230	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
37	Automatic shoe polishing machine	24300	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
38	Egg shell peeling machine	12000	2018	2	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
39	Design and fabrication of portable drain cleaning machine	11000	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
40	Design and fabrication of regenerative shock absorber	3240	2018	3	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
41	Fabrication of hybrid system	20000	2018	3	(7) Affordable and Clean Energy,

	for solar and wind				(9) Industry, Innovation and Infrastructure
42	Fabrication and experimental investigation on closed loop pulsating heat pipe	28000	2018	3	(9) Industry, Innovation and Infrastructure
43	Hot air jet machining	23000	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
44	Computational analysis on various fins	2400	2018	2	(9) Industry, Innovation and Infrastructure
45	Micromachining using ultrasonic vibration assisted electrical discharge machine EDM	15000	2018	3	(9) Industry, Innovation and Infrastructure
46	Plastic injection molding	12000	2018	2	(9) Industry, Innovation and Infrastructure
47	Assistive exoskeleton arm	8000	2018	3	(10) Reduced Equality (9) Industry, Innovation and Infrastructure
48	Development of a soya bean oil based cutting fluid for turning of EN8 steel	5000	2018	3	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
49	Solar agro sprayer with sun tracking system	32000	2018	3	(9) Industry, Innovation and Infrastructure, (15) Life on Land
50	Walker with adjustable legs	24000	2018	3	(10) Reduced Equality (9) Industry, Innovation and Infrastructure
51	Indoor air purifier	6000	2018	2	(3)Good Health and Well-Being, (9) Industry, Innovation and Infrastructure,
52	Automatic cylindrical water tank cleaning machine	13000	2018	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
53	Design and fabrication of economical electric auto-rickshaw	50000	2018	3	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
54	Design, fabrication and experimental investigation on a PEM fuel cell	41000	2018	3	(7) Affordable and Clean Energy, (9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
55	Design and fabrication of aqua silencer.	9000	2018	3	(9) Industry, Innovation and Infrastructure
56	Design and fabrication of cooling helmet using Peltier effect	5000	2018	3	(3) Good Health and Well-Being, (9) Industry, Innovation and Infrastructure
57	Design and fabrication of refrigeration system using IC engine waste heat	8815	2017	2	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
58	Generation of electricity from exhaust gas of a bike	9169	2017	2	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
59	Design and fabrication of coconut grating machine	3410	2017	2	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
60	Multi-purpose cleaning machine	5134	2017	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
61	Portable Arrowroot Grinding Jar	3600	2017	3	(9) Industry, Innovation and Infrastructure
62	Automatic ironing machine	20167	2017	3	(9) Industry, Innovation and Infrastructure

63	Design and fabrication of automatic seat belt	5185	2017	3	(3) Good Health and Well-Being, (9) Industry, Innovation and Infrastructure
64	Advanced flat tire changing mechanism	1729	2017	3	(9) Industry, Innovation and Infrastructure
65	Design, analysis and fabrication of a fish descaler	2630	2017	2	(9) Industry, Innovation and Infrastructure
66	Design and fabrication of wall plastering machine	39065	2017	3	(9) Industry, Innovation and Infrastructure
67	Smart water purifier using exhaust heat in automobiles	4300	2017	3	(6) Clean Water and Sanitation, (12) Responsible Consumption and Production
68	Design and analysis of multi-spring HN-3 actuator	3200	2017	2	(9) Industry, Innovation and Infrastructure
69	Effect of bipolar plate flow channel on the performance of a proton exchange membrane fuel cell: A numerical study	2600	2017	2	(9) Industry, Innovation and Infrastructure
70	Design and analysis of manual rice planter	2200	2017	2	(8) Decent Work and Economic Growth
71	Design of fire fighting system for petroleum storage tank	42000	2017	6	(3) Good Health and Well-Being, (8) Decent Work and Economic Growth
72	Roof drain system failure analysis in floating roof petroleum storage tanks	23000	2017	2	(8) Decent Work and Economic Growth
73	Design and fabrication of plastic bottle shredding machine	6000	2017	3	(8) Decent Work and Economic Growth
74	Development of microclimate personal cooling system based on thermoelectric effect-cooling jacket	5600	2017	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
75	Tetrapod assisting machine (T.A.M)	11400	2017	3	(8) Decent Work and Economic Growth, (15) Life on Land
76	Vibration analysis on centrifugal pump	6000	2017	2	(12) Responsible Consumption and Production
77	Experimental investigation on micro electro-discharge machining process	5000	2017	2	(12) Responsible Consumption and Production
78	Autonomous tire pressure maintenance system	8500	2017	3	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
79	Thermal analysis and efficiency improvements in solar panels	5000	2017	2	(7) Affordable and Clean Energy, (12) Responsible Consumption and Production
80	Fabrication of paper recycling machine	13200	2017	3	(12) Responsible Consumption and Production
81	Design and fabrication of micro ECM experimental setup	31000	2017	3	(9) Industry, Innovation and Infrastructure
82	On board weigh scale	2800	2017	3	(9) Industry, Innovation and Infrastructure
83	Influence of strain rate and solution ageing on CFRP and its recycling	6900	2017	2	(12) Responsible Consumption and Production
84	Fabrication of floor cleaning machine	21500	2017	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
85	Adaptive steering controlled headlight	5800	2017	3	(9) Industry, Innovation and Infrastructure

86	Supercharging of single cylinder engine	26000	2017	2	(9) Industry, Innovation and Infrastructure
87	Productivity improvement in KSE limited	50000	2016	3	(9) Industry, Innovation and Infrastructure
88	Pavement tile remolding machine	18790	2016	3	(9) Industry, Innovation and Infrastructure
89	Development and fabrication of customized grass trimmer	31000	2016	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
90	Rubber tapping knife	1200	2016	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
91	Machining of glass using abrasive air jet	11300	2016	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
92	Stair climbing wheel chair	26000	2016	3	(9) Industry, Innovation and Infrastructure, (10) Reduced Equality
93	Sensor based inspection conveyer	11700	2016	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
94	Performance analysis of domestic refrigeration using phase change material- An experimental study	1839	2016	2	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
95	Design and fabrication of label pasting machine for tapered glass containers	15000	2016	3	(8) Decent Work and Economic Growth
96	Design and cost estimation of plate heat exchanger	7000	2016	2	(9) Industry, Innovation and Infrastructure
97	Investigation on heat transfer properties of nano fluid using Michelson interferometer	6890	2016	2	(9) Industry, Innovation and Infrastructure
98	Power ramp	16500	2016	3	(7) Affordable and Clean Energy, (12) Responsible Consumption and Production
99	Design and fabrication of energy recovery system during braking	13700	2016	3	(12) Responsible Consumption and Production
100	Casting and analysis of aluminum (A6061) fly ash metal matrix composite	4800	2016	2	(9) Industry, Innovation and Infrastructure
101	Design and fabrication of passenger seat with integrated seat belts for cars	14500	2016	3	(3) Good Health and Well-Being, (9) Industry, Innovation and Infrastructure
102	Fire fighting robot	18500	2016	3	(3) Good Health and Well-Being, (8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
103	Investigation on electrochemical discharge machining	4200	2016	2	(9) Industry, Innovation and Infrastructure
104	LPG as fuel and refrigerant in automobile	7380	2016	2	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
105	Automobile power window and A/C integration	9400	2016	3	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
106	Design and analysis of	2600	2016	2	(8) Decent Work and Economic Growth,

	automatic fabric cutting machine				(9) Industry, Innovation and Infrastructure
107	Design and analysis of screw conveyor	2580	2016	2	(9) Industry, Innovation and Infrastructure
108	Analysis of regenerative cooling in liquid propellant rocket engines	3640	2016	2	(9) Industry, Innovation and Infrastructure
109	Dynamic analysis of automobile drive shaft at on-road condition	4880	2016	2	(9) Industry, Innovation and Infrastructure
110	Span morphing wings	1950	2016	2	(9) Industry, Innovation and Infrastructure
111	Heat rate reduction using waste heat at NTPC	4,83,000	2016	6	(9) Industry, Innovation and Infrastructure, (12) Responsible Consumption and Production
112	Manufacturing of integral bed and base for stallion 100s machine	97,240	2016	6	(9) Industry, Innovation and Infrastructure
113	Preparation and characteristics of banana reinforced phenol formaldehyde composite	6800	2015	2	(9) Industry, Innovation and Infrastructure
114	Fabrication and property investigation of coir reinforced composite	10050	2015	3	(9) Industry, Innovation and Infrastructure
115	Hydraulic liner puller for automobile engines	9250	2015	3	(9) Industry, Innovation and Infrastructure
116	Design and fabrication of a general purpose portable mini-hydraulic turbine	3350	2015	3	(9) Industry, Innovation and Infrastructure
117	Design and fabrication of low cost solar water heater	14000	2015	3	(12) Responsible Consumption and Production
118	Automatic tire inflation system for automobiles	16000	2015	3	(9) Industry, Innovation and Infrastructure
119	Accelerometer controlled wheel chair	14400	2015	3	(9) Industry, Innovation and Infrastructure
120	Solar based cutting machine	15000	2015	3	(8) Decent Work and Economic Growth, (12) Responsible Consumption and Production
121	Oxy-hydrogen fuel system	1500	2015	2	(9) Industry, Innovation and Infrastructure
122	River turbine	11000	2015	3	(7) Affordable and Clean Energy, (12) Responsible Consumption and Production
123	Leaf Shredder	13200	2015	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
124	Reverse mechanism in two wheeler for physically disabled	3500	2015	3	(10) Reduced Equality, (9) Industry, Innovation and Infrastructure
125	Peltier heating and cooling jacket	3720	2015	2	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
126	Power generation from vehicle suspension	11000	2015	3	(7) Affordable and Clean Energy, (12) Responsible Consumption and Production
127	Bamboo fiber based phenol formaldehyde composite material	8600	2015	2	(9) Industry, Innovation and Infrastructure
128	Experimental investigation of	5800	2015	2	(9) Industry, Innovation and Infrastructure,

	coconut oil as a lubricant				(12) Responsible Consumption and Production
129	Effect of magnetic fuel energizer on SI engine	6200	2015	2	(9) Industry, Innovation and Infrastructure
130	Automobile fire safety system	2350	2015	2	(9) Industry, Innovation and Infrastructure
131	Smart tool selector multi-axis robot	8700	2015	3	(9) Industry, Innovation and Infrastructure
132	Design, analysis and fabrication of a coconut dehusking machine	16500	2015	3	(8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure
133	Analysis of flow through convergent divergent nozzle using CFD	1900	2015	2	(9) Industry, Innovation and Infrastructure
134	Numerical investigation of bipolar plates in proton exchange membrane fuel cell	1570	2015	2	(9) Industry, Innovation and Infrastructure
135	Design analysis of three way unloading tipper	2230	2015	2	(9) Industry, Innovation and Infrastructure
136	Design and analysis of gating system of butterfly valve	38000	2015	6	(9) Industry, Innovation and Infrastructure
137	Modified process layout of split cam manufacturing	56000	2015	3	(9) Industry, Innovation and Infrastructure
138	Design and analysis of windmill hub manufacturing	8600	2015	3	(7) Affordable and Clean Energy, (9) Industry, Innovation and Infrastructure
139	Design of pressure vessel	7900	2015	3	(9) Industry, Innovation and Infrastructure

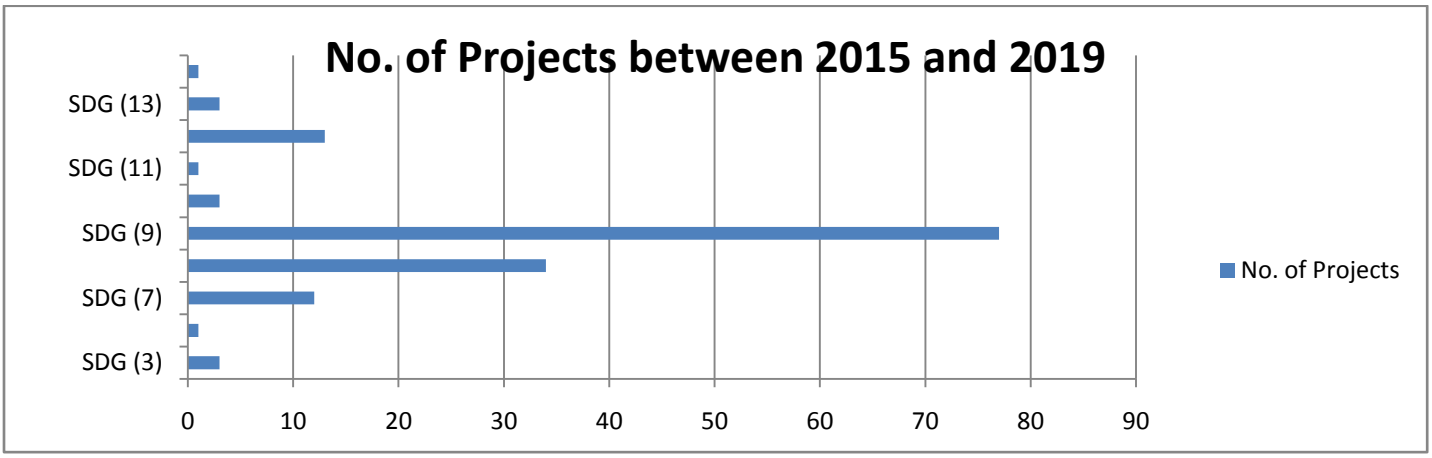

Figure 3: Graph – SDGs Vs Number of projects

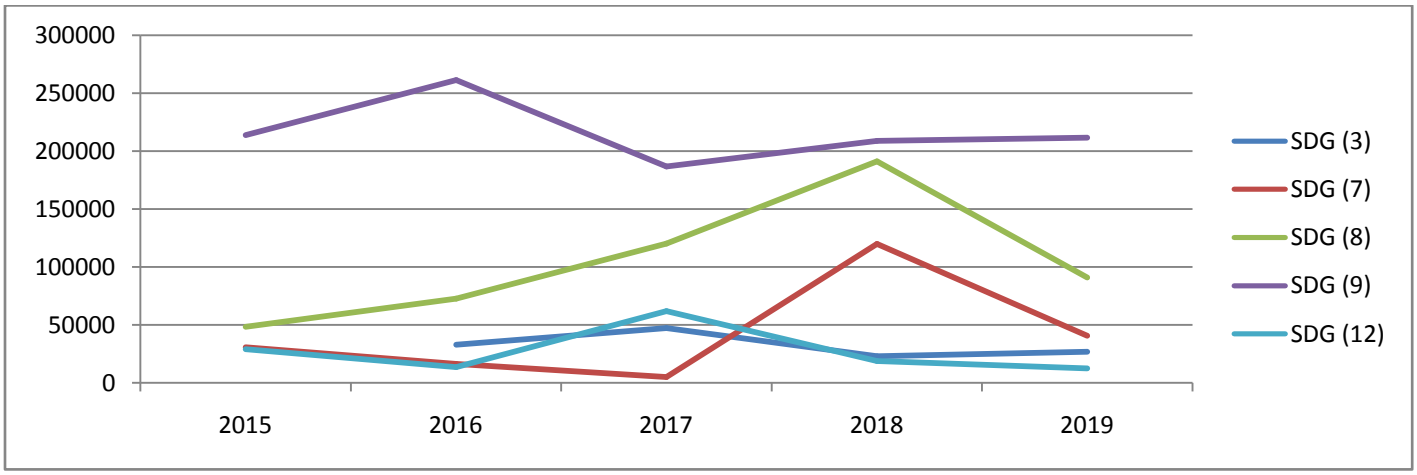

Figure 4: Net amount of fund spent on each SDG Vs Academic Year

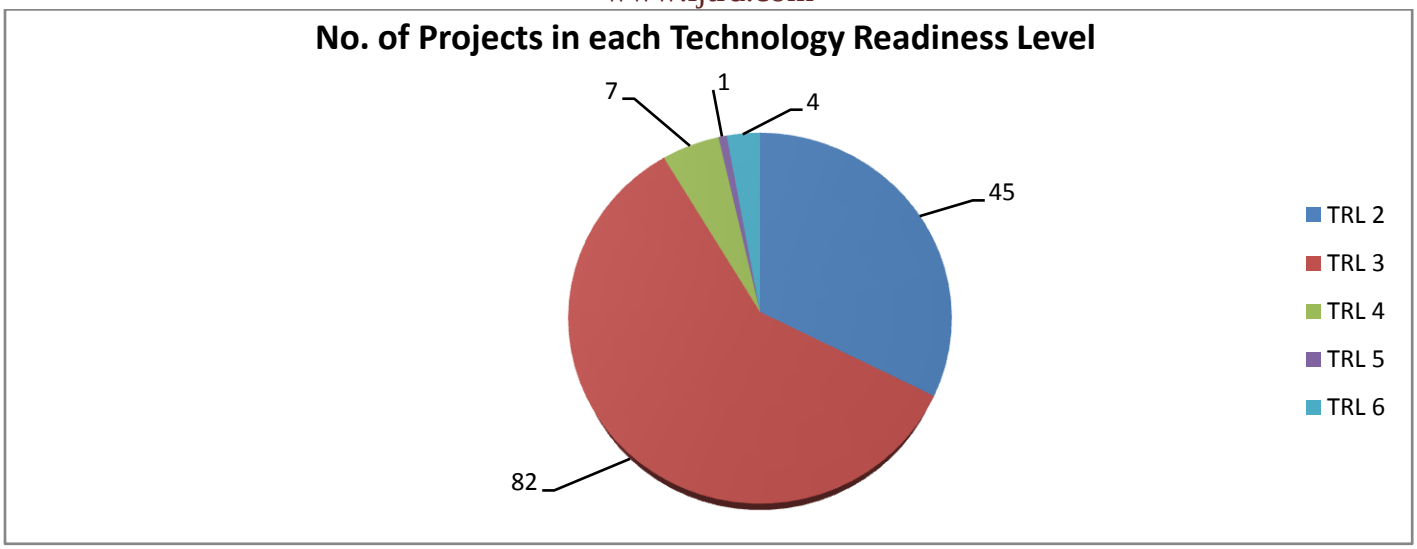

Figure 5: Technology Readiness Level and Number of projects

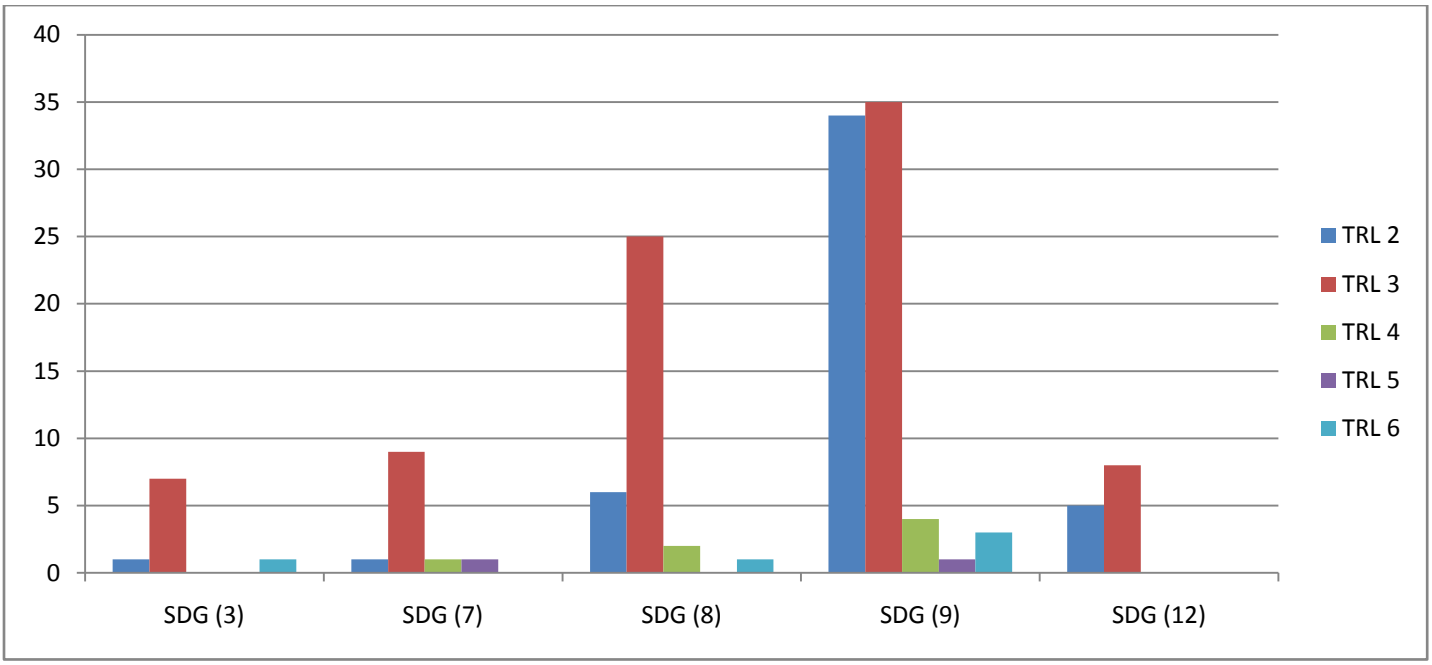

Figure 6: Number of projects Vs TRLs of each SDGs

According to the data collected from the college, 139 mechanical engineering projects were developed by students during the past 5 year period. Out of these projects majority of the projects, about 77 projects were in the SDG category (9), Industry, Innovation and Infrastructure. Meanwhile, in terms of the TRLs, most of the projects, about 82 projects, were in the TRL 3 stage. The graph below (Fig. 3) represents the number of projects in each SDG categories.

The line chart (Fig. 4) represents the net amount of fund spent on each SDGs during the past 5 years. SDG 9 (Industry, Innovation and Infrastructure) was the category with most expenditure due the high number of projects done in the category.

The above pie chart (Fig. 5) represents the proportion of projects at each Technology Readiness Level. More than half of the total projects were at TRL 3 stage.

The above bar graph (Fig. 6) represents the Technology Readiness Levels (TRL) of projects in each Sustainable Development Goal (SDG) categories. The development of renewable energy projects can be evaluated by examining the contribution in the SDG category (7) Affordable and clean energy. It can be observed from the data that more students tend to do renewable energy projects in 2018 when compared with 2015. However, the number of renewable energy technologies developed is not significantly high.

CONCLUSION AND RECOMMENDATIONS

This paper discussed about the importance of Sustainable Development Goals and Technology readiness levels in engineering projects. The paper includes the database of SJCET mechanical engineering student projects from 2015 to 2019. This database was used for analyzing the maturity and social responsibility of the projects. From the detailed study conducted, it was understood that about 55% of the projects were under the SDG category (9) – (Industry, Innovation, and Infrastructure). Also, in terms of TRL, about 59% were in the TRL 3 stage. However, renewable energy and SDG (7) – (Affordable and

Clean Energy) need to be concentrated more in order to bestow more innovations and discoveries in the sector. Colleges and universities must encourage students to develop their projects into at least TRL 4 by starting their projects early, with required resources, so that the project would be mature enough for commercialization by the end of their course. Also, students should be encouraged to take up projects that involve social responsibility and sustainable development. Besides, research and development in renewable energy can be accelerated by providing industrial exposure to students. Industrial talks by renewable energy entrepreneurs must be conducted periodically for students. They must be given opportunities to work in industrial projects to gain knowledge about the current technologies and scenarios. Outreach programs and rural electrification initiatives must be taken in order to make students aware about real life problems and solutions.

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