Sustainable Energy Entrepreneurship in India: The Transformative Role of Education

Amarendra Kumar Dash, Nihar Ranjan Agasti, Vivek Kumar, Rashmi Ranjan Behera and Rajendra Kumar Dash*

Abstract: Modern economies are heavily dependent on business and industrialization. A steady supply of energy at an economical price is crucial to all industrial activities. Moreover, industrialization in the 21st century is being re-conceptualized from the optic of sustainable development. Starting with the Rio Conference (1992) and gaining momentum through the Paris Agreement (2015), governments worldwide are taking a lot of measures to ensure eco-friendly development and inclusive growth that can be equally rewarding to people, profit, and the planet. Accordingly, there is a remarkable shift in focus from the conventional sources of energy such as fossil fuel to a spectrum of more sustainable and renewable sources such as solar, wind, tidal, geothermal, and biomass. Energy sources such as hydroelectricity projects and nuclear power plants are mostly government-driven. Energy sources such as geothermal projects, biomass, solar, wind, or tidal energy projects are open to private investments. The private sector consists of several players: large scale industries, MSMEs, or individuals. To sum up, modern economies need sustainable energy entrepreneurs to keep them thriving. In this perspective, a developing country like India, with huge potentials and aspirations to emerge as a developed nation, needs thousands of sustainable energy entrepreneurs to keep the India growth story alive. In

* Amarendra Kumar Dash (✉)
Department of English, RGUKT Nuzvid, AP, India
e-mail: dash_amarendra@yahoo.co.in (corresponding author)
Nihar Ranjan Agasti (✉)
Department of MBA, Gandhi Institute for Education & Technology, Khordha, India
Vivek Kumar (✉)
Department of Chemical Engineering, RGUKT RKV, AP, India
Rashmi Ranjan Behera (✉)
School of Social, Financial, and Human Sciences, KIIT University, Bhubaneswar, India
Rajendra Kumar Dash (✉)
Department of Basic Sciences & Humanities, GMRIT Rajam, AP, India

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this context, this paper discusses the importance of training and education to promote sustainable energy entrepreneurship in India.

Keywords: energy entrepreneurship, energy policy, renewable energy, entrepreneurial education, development communication

STATEMENT OF PROBLEM AND OBJECTIVES

An emerging economy, India is in quest of a continuum of energy sources and access to electricity that would cater to seamless industrial activities to survive in a competitive global market. The government in the last six years has focused on eco-friendly, import substitute, and indigenous mode of development. This new approach is believed to deliver greater autonomy to the nation and generate higher levels of economic value and quality of life. Moreover, India also needs a massive supply of fuel and energy for the domestic use of its 1.4 billion populations.

In recent years, under the auspices of the Narendra Modi government, India's accomplishments in the clean energy segment have been exceptional. Policy reforms and their implementation have resulted in a quantum leap forward towards "a secure, affordable and sustainable energy system to power a robust economic growth" (International Energy Agency 2020, 3). On one side, the nation has taken several initiatives to guarantee that every citizen has electricity for his needs by providing electric power to more than 700 million people since 2000 (International Energy Agency 2020). On the other, it is striving to reduce its carbon footprints through significant investments in renewable energy, especially solar energy, and energy efficiency schemes such as the Ujjala scheme that promotes the LEDs technology. Addressing the issue of air pollution and public health, the nation has provided 80 million LPG connections under the scheme called *Pradhan Mantri Ujjwala Yojana* and has been offering huge subsidies to citizens buying electric vehicles.

The government of India has facilitated a noticeable reduction in the biomass used for cooking which acts as a chief contributor in the indoor air contamination in India. Safe cooking practices using liquefied petroleum gas and off-grid solar energy are specifically promoted by the government with massive subsidies and with an ever-improving supply chain. Encouraged by the positive results, the government has been working steadily to absorb market-linked solutions through energy sector reforms and the positive participation of private players in the clean energy segment.

India has been moving towards meeting the UN Sustainable Development Goal number 7 by promoting citizen's access to energy remarkably. Besides, qualitatively, the intensities of emissions of India's gross domestic product (GDP) have come down beyond 20% during the last 10 years. Although the level of carbon dioxide (CO_2) emissions goes on increasing, India's per capita emission, 1.6 tonnes of CO_2, is far behind the global median of 4.4 tonnes that is just 6.4% of the global total (IEA 2020).

As a part of its commitments under the Paris Agreement, India has adopted several measures to reduce its emission intensity including greater use of non-fossil fuels for power and increased forest and tree cover. This has resulted in a steady decline in the emissions intensity of India's GDP. However, a sustained evolution towards electricity supply from non-carbon sources will remain a test of India's environmental stewardship.

India's tryst with sustainable energy can be envisaged in its scalar achievements. With its renewable power generation reaching 62 GW in 2017, India occupied the fourth position in wind and sixth in solar power in terms of globally installed capacity. Solar power was available at Rs. 2.44 per unit and wind power for Rs 2.64, the lowest of all time. Also, the Government projected to reach 100 GW solar power and 60GW of wind power capacity by 2020. In its 2017 notification, the Government of India expressed its target to achieve 175 GW of total installed capacity renewable energy by 2022 (Government of India 2017).

India, of late, has surpassed many developed nations in clean energy investment and, currently, it ranks fourth in renewable power generation (REN21, 2020). As of 2020, it produces 134 MW of energy from renewable sources. Despite such achievements in the clean energy domain, India has to worry about maintaining its quality of life on several fronts:

— India is destined to take over the European Union as the world's third-largest energy consumer by 2030 (IEA 2021). India is yet to see what can be called true industrialization. Ninety per cent of India's buildings, factories, power plants, industrial complexes, and vehicles are yet to be developed. In the future, sustained industrialization and urbanization will ask for an enormous quantity of energy. Benefiting from its demographic dividends and a large number of working populace, India is poised to become a

nine trillion USD GDP, with a per capita GDP rising to USD 5,625 by 2030 (CBRE 2019).

— India's GHG emissions have doubled between 1990 and 2015 (+147%) (TERI, 2018), and the trajectory is likely to continue, leading to be doubled by 2030 (Dubash et al. 2018).

— India has set a mammoth target of becoming a 100% e-vehicle nation by 2030, but it does not have the cutting edge technology, especially, the technology and resources required for electric battery and inverter.

— India is a party to the Copenhagen negotiations that compels it to cut down its emissions by 20–25% in 2020, from the 2005 levels. Although India's per capita emissions will be far behind the developed nations, on a more proactive note, it targets 40% of the total electricity to be produced from sources other than fossil fuel, by 2030.

— The India of 2030 will witness about a 75% increase in the number of buildings compared to 2020. To manage the continuous supply of energy to these buildings and, simultaneously, to maintain a respectable score in CO_2 savings will be a gargantuan task. The buildings of the years to come have to be energy efficient in consonance with the revised Energy Conservation Building Code (ECBC), 2017 of the Ministry of Power (MoP) and Bureau of Energy Efficiency (BEE) that targets 50% reduced energy use.

— On top of this, the national, state, and local self-governments have to come up with sustainable urbanization focused on quality of life for all, with greater sensitiveness to the needs of vulnerable urban communities. Routine needs such as employment, law and order, housing, sanitation, healthcare, and education will demand a lot of energy input and, more than that, effective planning, resource mobilization, and community involvement to ensure service for all stakeholders.

While the quantitative and qualitative supply of energy remains important, the availability of energy at competitive and affordable prices will be a matter of special concern for India. As a whole, the whole issue will remain subject to technological innovation. In this scenario, technology transfer through international collaboration and alliances will remain an obvious choice. However, no country would like to share its latest technology with another country on fair exchange principles. To remain competitive and innovative, India has

to invest significantly in research and development. In this context, education for renewable energy entrepreneurship can be a course changer for India.

The knowledge spillover theory of entrepreneurship (Agarwal et al. 2007, 2010) and related concepts of entrepreneurial ecosystems and innovation framework (Markard and Truffer 2008; Audretsch and Berlitski 2013; Stam 2015; Theodoraki et al. 2018) advocate in favour of multi-stakeholder governance and knowledge diffusion in the context of entrepreneurship development. Accordingly, leaders from academics, industry, and regional development bodies should come together in win-win negotiations to invest significantly in knowledge creation and management leading to the creation of robust entrepreneurial ecosystems.

Education is the cornerstone of all developmental activities including entrepreneurship. Education can help aspiring entrepreneurs to understand the industrial ecosystem and market dynamics as well as the key drivers of success in the renewable energy sector. This, in turn, will help them to better prioritize their efforts and investments in clean energy production and distribution by understanding the gains relative to the risk to be undertaken. The entrepreneur needs to understand the techniques for efficient production, storage, and competitive supply chain of clean energy. S/he has to understand the optimization of natural and human resources; issues related to the availability of capital and cutting edge technology; quality management and innovation; collaboration for technology transfer and commercialization; minimization of wastage; and the value of automation and use of artificial intelligence. The entrepreneur has to be well versed in the latest business models. While a fair knowledge of public policy enables the entrepreneur to understand the macro-economic scenario, target market analysis and outreach helps in understanding the needs of the customers. Education plays a vital role in the dissemination of all these critical knowledge and skills that empowers the entrepreneur to take strategic decisions and need-based innovations. Against this backdrop, this aim of this article is to substantiate the transformative role of training and education for the new generation of sustainable energy entrepreneurs of India.

THE SCOPE OF SUSTAINABLE ENERGY ENTREPRENEURSHIP EDUCATION

Entrepreneurship education aims at inculcating the knowledge, skills, and values in the students that can help them to lead business and trades to ensure prosperity and welfare in a competitive and fast-changing world. It makes the students familiar with the latest knowledge in the field of Human Resources, Finance, Marketing, Production and Operation, Quality Assurance, and Internet and Communication Technologies. It teaches students critical life skills such as collaboration and team-building, public speaking and presentation skills, data analysis, social media tools for advocacy, problem-solving, and creativity and innovation. In addition to knowledge and technical skills, the primary goal of entrepreneurship education should be to strengthen the inner morals and reshape the worldviews of students so that they can ingrain the leadership behaviour such as goal orientation, process orientation, system thinking, decision making, negotiation, motivation and influence, welfare orientation, and sustainable development. It nurtures self-confidence, work culture, competitive spirit, and motivation for excellence. It prepares the students to face real-life challenges by making them familiar with national and international business policies and practices and business eco-systems and inter-cultural variations. Entrepreneurship education is simply not confined to the students of science, technology, and business. It has remained rewarding to people from the background of sports, arts, music, and humanities too.

The increased sensitivity to the environmental consequences of industrialization and urbanization has prompted world leaders to find eco-friendly and sustainable technologies. The much sought after transformation to sustainable development depends on the renewable energy sector. The role of the entrepreneurs to develop sustainable technologies for clean energy deems important. More efficient use of resources, minimal damages to the environment, and greater focus on the quality of life are the priorities before the energy entrepreneur. In a world of massive technological transformations and complex socio-political crises, entrepreneurs have to cope with the uncertain and the unpredictable twists and turns at any point in time. Therefore, entrepreneurship education should be dynamic enough to instill positive thinking, influencing, networking, and decision-making skills.

The majority of the world's clean and sustainable energy technologies are at the research and development stage across the

universities and other laboratories. The slow progress in the development and commercialization of clean technologies is a major barrier to innovative entrepreneurial engagements. Moreover, the new technology in the clean energy segment should be qualitative, dependable, and cost-effective to compete with the polluting but cheap and efficient fossil fuel energy. Although cost-effective in the long run, the renewable energy industry is capital intensive to start with. Knowledge spillover and opportunistic use of innovations by free-riders cause a serious threat to the original investor. Internalization of external costs results in increased cost of the technology. Therefore, the protection of intellectual property rights of the original innovator coupled with incentives and subsidies play a significant role in motivating the potential entrepreneurs to invest in renewable energy.

Public policy and regulation play a vital role in removing the barriers to renewable energy entrepreneurship discussed above. There are several stakeholders of renewable energy entrepreneurship. Coordinated efforts by the major stakeholders who assume responsibility for the development, commercialization, and diffusion of sustainable energy technologies are important. There are four major areas of sustainable energy entrepreneurship:

1. *Policy entrepreneurship:* The government is the key player.
2. *R&D entrepreneurship:* The universities, government scientific labs, and industrial labs dedicated research and innovation lead this sector.
3. *Clean energy production entrepreneurship:* Industries, corporations and municipalities, and NGOs or social entrepreneurs can play the vital role in this segment.
4. *Outreach Entrepreneurship:* Market researchers, NGOs, and organisations dedicated to public or customer relationship can contribute to communication and outreach strategies.

Access to education, especially customized education and training for the energy entrepreneurs is being looked upon as a major component of the policy framework nowadays. Education can empower the would-be entrepreneurs by imparting the knowledge, skills, and behavioural traits necessary for the adaptation to the clean energy paradigm. The global aspirations of a robust low carbon economy is beset with pressing issues such as the predictable supply of clean energy and the nature of energy mix, use, and efficiency. Renewable energy entrepreneurship is also challenging because of the absence of matured and publicly available technologies. This creates

an opportunity for the universities and training institutions to venture into multi-disciplinary collaborations for clean energy research and development and to offer various need-based, cutting-edge courses on the same.

IMPORTANCE OF SUSTAINABILITY IN ENGINEERING EDUCATION

India is a signatory to the Washington Accord that is committed to skill-based education emphasizing 12 Graduate Attributes. These attributes are: (1) knowledge base for engineering; (2) problem analysis; (3) ability for investigation; (4) ability to design solutions for complex problems, systems, components or processes; (5) use of engineering tools; (6) individual and teamwork; (7) communication skills; (8) professionalism; (9) impact of engineering on society and the environment; (10) ethics and equity; (11) economics and project management; and (12) life-long learning. On behalf of India, the National Board of Accreditations is the designated authority to inspect and certify the quality and efficacy of higher education institutions to comply with desired global standards. Based on an in-depth reading of the 12 Graduate Attributes, it is understandable that they serve as the foundation for any entrepreneurial education.

The UNESCO's Education for Sustainable Development (ESD) envisions the transformation of traditional pedagogies into a cradle of sustainable development by incorporating the appropriate knowledge, skills, and values in school education. The school that promotes this approach partakes in the new social learning and collective movements (Lotz-Sisitka et al. 2015). To start with, the governance of the school should be open to conducive to dialogues and conversation and student-centred approaches (Kelley and Dikkers 2016). The whole school approach to education for sustainability is founded on the student's ability to respond to the uncertainties and complex problems around and to look out for innovative solutions (Mogren, Gericke, and Scherp 2018). Therefore, the school education must be dynamic enough to inculcate multiple perspectives such as cultural, structural, political, transformational and cognitive approaches to sustainability (Bolman and Deal 1991).

Compared to any high school, an engineering college of India is better equipped to adapt to education for sustainability. What is missing is stringent regulation and institutional will power. Public institutions like The University Grants Commission, The All India

Council for Technical Education, and all other regulating bodies must come forward with transactional and transformative plans on education for sustainability. Educating the members of the Governing Council of the college and making them responsible for the transformation to sustainability education should be the next step. Sustainability as a principle must inform each element of engineering education from infrastructure to pedagogy. Against this backdrop, this study proposes a convergence of principles and practices demonstrating a *whole-school approach* to engineering education for sustainability:

1. *Accreditations:* Sustainability must be adopted as the guiding principle in national accreditations for the rating of colleges and universities.
2. *Collaboration:* This should lead to industry-academia collaboration for knowledge and technology co-creation and international inter-institutional collaborations for the co-production or transfer of green technologies.
3. *Green buildings and green campus:* Universities must adopt model infrastructure with natural light and ventilation or powered by renewable energy.
4. *General curriculum:* Universities must redesign engineering curriculum from the lens of sustainability.
5. *Electives:* The curriculum of elective subjects must focus on case studies and in-Lab simulations and experiments with a major thrust towards environmental sustainability.
6. *Continuous activities:* Sustainability should be the key driver of campus events such as essay, debate, and quiz competitions, and exhibitions and road shows etc.
7. *Study tours:* Schools, centres, and departments should be directed to arrange visits to organisations dedicated to sustainable technologies or principles.
8. *Internship:* Students should be encouraged to take up summer or long-term internships on sustainable technologies.
9. *Entrepreneurship Development Cell:* The cell must train and motivate students to develop and lead sustainable enterprises.
10. *R&D Projects:* University must incentivize faculty research and sponsored projects on sustainability.

EDUCATION FOR SUSTAINABLE ENERGY ENTREPRENEURSHIP

Access to electricity has brought about significant economic value and quality of life in India. Having realized this, the next big drive before the nation is to keep up the quality of life by sustainable development. One of the best principles in this end is "Catch Them Young". The young undergraduate engineering students can be groomed as future actors and leaders of India's sustainable development. They must have a fair understanding of the drivers and constraints of the clean and renewable energy industry which is the lifeline of sustainable development.

According to Gabriel (2016, 262), renewable energy enterprises in developing countries are stuck with six major challenges: (1) inadequate access to institutional finance; (2) the price of renewable energy technologies (RETs); (3) the lack of skilled labour; (4) underdeveloped physical infrastructure and logistics; (5) power/dominance of incumbents; and (6) inadequate government or policy support. Research (Abrams et al. 2019) supports that India has, to a great extent, overcome several challenges such as attracting private investment, revenue collection strategies, customers' paying capacity, distribution and utility infrastructure, domestic energy policy and institutional support, and the structural issues restraining the renewable and clean energy industries. Despite the success, India's clean energy enterprises are struggling on several fronts such as the availability of long term investors, talent attraction and retention, consumers' education and awareness, and strategic partnership.

According to Koubaa (2017), whereas imperfections in the market place create the scope for innovations towards sustainability, the lack of *absorptive capacity* of a firm may hinder this move. *Absorptive capacity* (Cohen and Levinthal 1990) refers to the capability of a firm to identify the value of external knowledge or information and to assimilate the same and, finally, to apply the knowledge system to gain commercial dividends. In this regard, the four major pressing issues before the sustainable energy entrepreneur are (1) achieving **e**nergy efficiency, (2) developing smart grids and energy systems, (3) renewables' integration, and (4) developing reliable technology for energy storage. These challenges are often mutually co-related:

1. *Energy Efficiency:* The goal is to reduce harmful emissions and bring improvements in unit cost. The major challenge in this direction is the availability of affordable technology.

2. *Smart Grids and Energy Systems:* The goal is the better management of power flows. The major challenge is how to overcome the vulnerable to hacking.
3. *Renewables Integration:* The goal is to obtain decentralized power generation from renewable sources. The major challenges are intermittencies and system-balancing.
4. *Storage:* The goal is to achieve 24X supply of power and mitigation of power uncertainties. The major challenge is the high cost and low availability of battery and inverters.

Energy intensity is measured by the quantum of energy necessary to produce or transport a unit of goods and/or services. Improvements in the efficiency of energy result in lower energy intensity. Large scale improvements in energy efficiency are considered as one of the ways of addressing climate change issues. In addition to the reduction in polluting emission level, energy efficiency helps in cost-cutting and better economic competitiveness. For the countries going through faster industrialization, it boosts demand growth, system reliability, ease of supply, and the overall development and expansion of the infrastructure for energy production and distribution. Small, incremental and cumulative progress in the efficient use of energy over a long period can fasten the economic transition of a country to a more productive and competitive phase.

There are several challenges to attaining optimum energy efficiency. Grueneich (2015, 44) outlines five crucial factors such as (1) improvements in the scale of savings; (2) diversification of energy efficiency resources; (3) capacity to evaluate and ensure the steadiness of savings from energy efficiency; (4) integration of the savings with a carbon reduction framework; and (5) understanding the systemic importance of energy efficiency in an emerging grid.

Smart grid technology is a modern version of the conventional power grid. It is automated with computers and ICT because of which it can fast track the communication among energy retailers, distributors, and customers. Smart grids are useful in integrating a greater amount of renewable energy sources (RES) into the grid. They can monitor and regulate power flows at each stage of the cycle from power generation to distribution to consumption, and thus, can leverage in wastage reduction and cost-saving. Above all, smart grid techniques improve the efficacy of the intermittent generation of renewable energy in hybrid and integrated power grids consisting of hydro, solar, wind, and tidal energy.

Renewable energy integration aims at developing system design, planning and operation of the electric grid to use energy from diverse renewable sources through decentralization. However, the major fallouts of the large scale integration of distributed photovoltaic (PV) solar power are voltage violations and reverse power flow in low-voltage distribution systems. High-renewable micro-grids are usually vulnerable to intermittencies and system-balancing issues. These issues necessitate caution and planning, diligent automation, robust storage capacity, and the development of many other adaptive technologies.

Some of the renewable energy projects such as wind and solar have variable outputs. Appropriate storage technologies are required to maintain the ease of power supply from the point of generation to the consumption destination while preserving the demand-supply equilibrium. Nowadays, batteries, especially lithium-ion technology, are getting popular as a convenient storage system. However, the battery technology is also beset with short term and long term challenges. In the short run, while the exorbitant cost and large size of the batteries raise the issues of economic viability and space management, the scant availability of raw materials like lithium makes the projects import-dependent. In the long run, the environmental impact of the millions of dead batteries raises alarms about the end of life solutions such as recycling and reuse. Against this backdrop, entrepreneurship education should provide various models of problem-solving to young engineering graduates and train them to develop the skills to solve complex and unfamiliar problems so that the learners can:

1. *Understand and apply:* The student must be able to learn from real world case studies, site visits, simulations, data analysis, and data-driven decision making methods.
2. *Innovate:* Learners must be able to inculcate problem solving and out of the box thinking so that they can develop appropriate technologies.
3. *Acquire:* The student must be able to negotiate for tech-transfer and collaborate, understand and benefit from the public policy for tech support.
4. *Accomplish the goal:* The student must be able to formulate strategies to cope with emerging challenges.

Besides technological issues, education for sustainable energy entrepreneurship should enable the learners to formulate strategies to manage other factors like huge upfront capital investment, lack of

dedicated financial institutes, politics and entry barriers, land acquisition and space management, and achieving the economy of scale and commercial viability.

In Germany, state universities are getting transformed from conventional teaching and research institutions to adopt a more responsible framework to steer up societal role in sustainable regional and economic development. The aim is to encourage knowledge spillovers to improve sustainable entrepreneurial ecosystems in the region. They are actively promoting the involvement of key stakeholders in critical governance processes at the regional level. Gathering insights from the German model, Wagner et al. (2019) demonstrate how, catering to the regional context, need-based configurations, pathways, and nodes of intervention may be designed to usher effective entrepreneurial ecosystems.

The European Entrepreneurship Summer School (EESS), for instance, aims at creating a learning community and space for inspired learners through diverse activities and coaching. This program brings together motivated participants with a wide range of experiences and skill sets to engage in intense mutual interaction and cooptation to compete and collaborate for group projects and presentations. The program serves as the pre-school groundwork for students to acquire the basic knowledge and techniques to be groomed as an entrepreneur (Chepurenko, Belousova, and Groen 2020).

In India, entrepreneurship courses are offered in a more focused way at M-Tech and MBA level. Many of NITs in India are floating two-year full-time M-Tech program in Renewable Energy. However, unlike B-Tech programs that involve industry internship and field visit, M-tech programs are campus-bound. Lack of collaboration with the industry and other actors seems to be the major handicap in this direction. Doctoral programs, on the other hand, can be tailored to integrate field studies and surveys with in-lab simulations and real-time experiments leading to innovations on sustainable energy technologies and their applications. Long term courses such as B-Tech, MS and PhD demand students to invest a significant amount of time and money. On the contrary, short term skill developments courses or workshops are also found to be useful for people who are otherwise busy but want to enhance their domain-specific knowledge and skills. Summer and winter schools on energy entrepreneurship can be hugely rewarding for mid-career professionals to benefit from the experiences of other participants and to build up networking.

One of the major drawbacks of entrepreneurship educations in India is the lack of focus on impact assessment. While the desire to endow students with the knowledge and competency through need-based programs is praiseworthy, monitoring the effectiveness of a program is a relatively grey area. Although universities are collecting students' feedback on faculty teaching, the same commitment is missing when it comes to collecting the feedback on the syllabus and the curriculum and the methods of teaching and examination. Going one step ahead, a statistical database on how many students have practically turned into entrepreneurs is missing. This attitude can be summed up as "Out of the campus is out of the mind". In effect, the real-time impact of the program can be monitored, to a great extent, by the Office of Alumni Affairs of the respective university. The feedback on the performance of the alumni vis-à-vis their constraints can be built into the entrepreneurship curriculum either as case studies or for challenging and revising the established models of entrepreneurship.

In India, the IITs and IIMs and other top-ranking private institutes have the potentials to make all-around contributions to sustainable energy entrepreneurship and innovation. Constructive feedback from industries and other field-based practitioners can be the starting point of designing an undergraduate or graduate program. Energy entrepreneurship is bound to be a cross-disciplinary area including Mechanical Engineering, Electrical Engineering, Environmental Engineering, Computer Science, Management and many other allied disciplines. The cross-disciplinary approach can provide holistic solutions to extant challenges by bringing together the knowledge and application of diverse energy technologies, systems, and structures of operation, value-added with insights on marketing and consumer behaviour, public policy and regulation, and the economic and cultural aspects of development.

CONCLUSION

Based on the public policy support and the predictable rate of growth, India's energy demand is supposed to double by 2040, with three times more demand for electricity because of the increased use of electronic appliances and refrigerators and air conditioners. The additional responsibility for tackling extreme climate change through emission control is the need of the hour. A need-based shift away from the fossil fuel regime means large scale generation of renewable energy alongside improvements in energy efficiency. India's cherished vision

of *electricity mix* includes 450 GW of contributions from renewable sources. This gigantic stride towards clean energy requires a lot of flexibility for successful system integration.

In consonance with the ambitious "Make in India" and "Make for the World" programs, research and development in the clean energy sector is positioned to be a strong enabler of several manufacturing initiatives through FDI and joint ventures and collaborations for technological transfer/innovations. The problem is that while policy reforms and fiscal support for FDI in the clean energy sector has proved to be a principal enabler, lack of skilled manpower, environmentally conscious consumers, and ambitious entrepreneurs at the bottom-line is a major worrisome factor. In this context, education for sustainable energy entrepreneurship is going to be a game-changer. Universities, colleges, training organisations, and NGOs should work in harmony to make this happen. The whole school approach to sustainability education proposed above can be a major leap forward at this end. The approach can be more pragmatic by integrating the social-emotional and behavioral aspects of learning with the traditional cognitive science-based education.

REFERENCES:

Abrams, E., Bosma, K., Carney, M. et al. 2019. *Business Models for Energy Entrepreneurship in Emerging Markets*. Master's Project. School for Environment and Sustainability, University of Michigan. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/148815/Business%20Models%20for%20Energy%20Entrepreneurship%20in%20Emerging%20Markets_P46.pdf?sequence=1&isAllowed=y [accessed 20.03.2021].

Agarwal, R., Audretsch, D., Sarkar, M.B. 2007. "The process of creative construction: knowledge spillovers, entrepreneurship, and economic growth". *Strategic Entrepreneurship Journal*, 1(3-4): 263–286.

Agarwal, R., Audretsch, D., Sarkar, M.B. 2010. "Knowledge spillovers and strategic entrepreneurship". *Strategic Entrepreneurship Journal*, 4(4): 271–283.

Audretsch, D. and Berlitski, M. 2013. "The missing pillar: the creativity theory of knowledge spillover entrepreneurship". *Small Business Economics*, 41: 819–836.

Bolman, L.G. and T.E. Deal. 1991. *Reframing Organizations: Artistry, Choice, and Leadership*. San Francisco, CA: Jossey-Bass.

CBRE. 2019. *India 2030 – Exploring the future* [Online]. https://www.cbre.com/research-and-reports/India-2030---Exploring-the-future#:~:text=India's%20demographic%20dividend%20and%20a,of%20USD%205%2C625%20by%202030 [accessed 20.03.2021].

Chepurenko, A., Belousova, O., Groen, A. 2020. "Educating prospective entrepreneurship researchers: the case of a summer school as a learning community". *Entrepreneurship Education*, 3(4): 393–410. https://doi.org/10.1007/s41959-020-00035-3 [accessed 20.03.2021].

Cohen, W.M., Levinthal, D.A. 1990. "Absorptive capacity: A new perspective on learning and innovation". *Administrative Science Quarterly*, 35(1): 128-152.

Dubash, N.K., Khosla, R., Rao, N.D., Bhardwaj, A. 2018. "India's energy and emissions future: an interpretive analysis of model scenarios". *Environmental Research Letters*, 13(7): 074018.

Gabriel, C.A. 2016. "What is challenging renewable energy entrepreneurs in developing countries?" *Renewable and Sustainable Energy Reviews*, 64: 362–371.

Grueneich, D.M. 2015. "The next level of energy efficiency: the five challenges ahead". *The Electricity Journal*, 28(7): 44–56. https://doi.org/10.1016/j.tej.2015.07.001 [accessed 20.03.2021].

IEA. 2021. *India Energy Outlook 2021: World Energy Outlook Special Report*. https://www.gita.org.in/Attachments/Reports/IndiaEnergyOutlook_WEO2015.pdf [accessed: 10.02.2022].

Kelley, C., and Dikkers, S. 2016. "Framing feedback for school improvement around distributed leadership". *Educational Administration Quarterly*, 52(3): 392–422.

Koubaa, S. 2017. "Renewable energy through the lens of entrepreneurship theory". *Projectics / Proyéctica / Projectique*, 18(3): 69–88.

Lotz-Sisitka, H., Wals, A., Kronlid, D., McGarry, D. 2015. "Transformative, transgressive social learning: rethinking higher education pedagogy in times of systemic global dysfunction". *Current Opinion in Environmental Sustainability*, 16: 73–80.

Markard, J., Truffer, B. 2008. "Technological innovation systems and the multi-level perspective: towards an integrated framework". *Research Policy*, 37(4): 596–615.

Mogren, A., Gericke, N., Scherp, H-Å. 2018. "Whole school approaches to education for sustainable development: a model that links to school improvement". *Environmental Education Research*, 25(4): 508–531.

REN21. 2020. *Renewables 2020 Global Status Report*, https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf [accessed: 10.02.2022].

Stam, E. 2015. "Entrepreneurial ecosystems and regional policy: a sympathetic critique". *European Planning Studies*, 23(9): 1759–1769.

Theodoraki, C., Messeghem, K., Rice, M.P. 2018. "A social capital approach to the development of sustainable entrepreneurial ecosystems: an explorative study". *Small Business Economics*, 51: 153–170.

UNESCO. 2021. *How can education strengthen climate action?* https://en.unesco.org/news/how-can-education-strengthen-climate-action [accessed: 10.02.2022].

Wagner, M., Schaltegger, S., Hansen, E.G., Fichter, K. 2019. "University-linked programmes for sustainable entrepreneurship and regional development: how and with what impact?", *Small Business Economics*, 56: 1141–1158.