

# Energy Literacy and Knowledge Transfer among Higher Institutions (HEIs) Students: Obstacles and Way Forward Towards Sustainable Development Goal (SDG)

Zeittey Karmilla Kaman<sup>1</sup>, Sidra Naim<sup>2\*</sup>, A M M Masrur Hossain<sup>3</sup> and Tamanna Khanm<sup>4</sup>

<sup>1</sup>Resident Faculty, Othman Yeop Abdullah, Graduate School of Business (OYAGSB), Universiti Utara Malaysia

<sup>2</sup>Senior Lecturer, College of Continuing Education (CCED) Universiti Tenaga Nasional (UNITEN), Malaysia

<sup>3</sup>Lecturer, Department of Business Administration, International Islamic University Chittagong (IIUC), Bangladesh

<sup>4</sup>PhD Student, College of Graduate Studies (COGS), Universiti Tenaga Nasional (UNITEN), Malaysia

<sup>1</sup>zeittey.karmilla@uum.edu.my, <sup>2</sup>sidra@uniten.edu.my, <sup>3</sup>masrur@iiuc.ac.bd and <sup>4</sup>tamannakhanm92@gmail.com

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## ABSTRACT

This paper examines the critical role of energy literacy and knowledge transfer within higher education institutions (HEIs) as key components in achieving the Sustainable Development Goals (SDGs). As global efforts to address environmental challenges intensify, promoting energy awareness and facilitating knowledge sharing in educational settings become essential strategies. These initiatives empower students to contribute actively to sustainable development, enhancing their ability to innovate and address energy-related issues effectively. The study sets three research objectives: first, to characterize the implementation of knowledge transfer through energy literacy in HEIs; second, to analyze the synergistic effects of energy literacy and knowledge transfer in advancing the SDGs; and third, to identify obstacles hindering these efforts in HEIs. Through a systematic literature review, this research highlights gaps in current knowledge, particularly concerning the SDGs. The energy literacy model helps students deeply understand energy concepts and apply them meaningfully, while Knowledge Transfer theory emphasizes cross-contextual knowledge application to prepare students for future challenges, supporting SDGs like climate action and sustainable cities. Transformative Learning theory involves progressing from awareness to action through dilemmas, reflection, and dialogue. Systems Thinking and Complexity theory emphasize understanding energy within complex socio-ecological systems, considering interconnected feedback loops and adaptability. By applying these theories, the paper benchmarks effective practices in energy literacy and knowledge transfer. The findings highlight the need for stakeholders to prioritize these areas in higher education, focusing on SDGs related to affordable and clean energy, sustainable cities, and climate action. This paper is crucial for HEI management, researchers, policymakers, and students, offering strategic insights into integrating energy literacy with SDGs, identifying research gaps, informing policy, and empowering students to tackle real-world challenges while fostering leadership in future sustainability practices.

**Keywords:** Energy literacy, knowledge transfer, HEIs, obstacles, and SDG.

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## 1.0 INTRODUCTION

In the pursuit of Sustainable Development Goals (SDGs), energy literacy and knowledge transfer among students at higher education institutions (HEIs) stand as pivotal components. As the global community strives to address pressing environmental challenges, cultivating energy awareness and promoting the flow of knowledge within educational settings are increasingly recognized as essential strategies. These efforts not only empower students to become proactive participants in sustainable development but also enhance their capacity to innovate and address energy-related issues effectively (Brondo et al., 2022).

Energy literacy involves understanding the nature and role of energy in the world, the economic and environmental impacts of energy production and consumption, and the importance of energy conservation. It equips students with the critical thinking skills necessary to make informed decisions, aligning with global efforts to promote affordable and clean energy; SDG 7 and combat climate change; SDG 13 (Garito et al., 2023). Meanwhile, effective knowledge transfer bridges the gap between academic knowledge and practical application, fostering community empowerment and sustainable urban development; SDG 11 (Quan et al., 2019). This article delves into the importance of energy literacy and

\*Author for Correspondence: sidra@uniten.edu.my

knowledge transfer at the tertiary level, exploring their roles in achieving the SDGs and proposing actionable strategies for educational institutions. Therefore, this paper aims to explore the obstacles faced by higher education institutions in promoting energy literacy and facilitating knowledge transfer, and to propose actionable strategies for overcoming these challenges. By identifying and addressing these barriers, the paper seeks to enhance the role of tertiary education in achieving SDGs, particularly those related to affordable and clean energy, sustainable cities, and climate action.

### 1.1 Scope of Study

Higher education institutions play a crucial role in promoting energy literacy and facilitating knowledge transfer, essential components in achieving sustainable development. Studies from around the world have highlighted various approaches and successes in this regard. This study employs a Systematic Literature Review (SLR) to synthesize existing research on energy literacy (EL) and knowledge transfer (KT) within higher education institutions (HEIs), guided by the PRISMA framework (Moher et al., 2009), a widely recognized standard for systematic reviews. The review focuses on three thematic areas: first, it explores how knowledge transfer through energy literacy is characterized in HEIs; second, it examines the synergistic effect of EL and KT in contributing to the achievement of the Sustainable Development Goals (SDGs); and third, it identifies obstacles in establishing EL and KT within HEIs. By addressing these areas, the study aims to provide a comprehensive understanding of the current landscape and opportunities for enhancing energy literacy and knowledge transfer in higher education.

### 1.2 Centrality of Higher Education Institutions (HEIs) to SDGs Achievement

Higher education institutions are at the forefront of efforts to achieve the Sustainable Development Goals (SDGs) through energy literacy and knowledge transfer. Previous studies can be referred to Awashreh, R. (2025) which emphasizes the importance of embedding sustainability, including energy literacy, into university curricula. This approach prepares students to address the complex sustainability challenges that align with the SDGs. Fia et al. (2022) provides a systemic review showing that universities worldwide are rethinking teaching, research, and outreach programs to support the SDGs. The study finds that most HEIs prioritize sustainability education and management, confirming their central role in driving SDG progress. This shift ensures that students not only learn about sustainability but also apply it in practical, impactful ways. By fostering interdisciplinary learning and active faculty engagement, universities enhance their students' ability to make informed decisions and innovate solutions for energy efficiency and renewable energy. Kuehl et al. (2023) through sustainability literacy focus highlights the increasing focus of HEIs on building students' knowledge of energy and sustainability issues. Many institutions now require sustainability courses and participate in international ranking systems that recognize and reward

these efforts, underscoring the importance of sustainability literacy in higher education. In terms of awareness and leadership development, according to Baron et al. (2024), HEIs serve as pivotal "knowledge disseminators, behaviour consolidators, and idea innovators." By incorporating sustainability across curricula and campus life, they foster awareness, engagement, and leadership for the SDGs. This process supports SDG 4 (Quality Education) which emphasizes on ensuring learners acquire sustainability knowledge. Pietrzak (2022), in his study highlights the role of public HEIs in Poland in advancing the SDGs in 2021. Universities are increasingly embracing the responsibility of promoting sustainable development, primarily by integrating sustainability concepts into their research and teaching activities. However, it appears that one of the most straightforward methods for promoting the SDGs is through the scholarly publications produced by academics by engaging into EL. Moreover, Filho et al. (2025) emphasized that HEIs, as centers of knowledge creation, interdisciplinary collaboration, and innovation, are uniquely equipped to promote sustainable communities with real-world impact. By incorporating sustainability into their curricula, institutional policies, and research agendas, HEIs adopt a systematic and comprehensive approach to sustainability. The findings of this study underscore how these institutions not only deepen academic understanding but also offer practical insights that can shape policymaking and the implementation of sustainable practices

### 1.3 The Importance of Energy Literacy and Knowledge Transfer in achieving SDGs.

In today's world, where sustainability is key, energy literacy and knowledge transfer are crucial to achieving the UN's SDGs. As we face climate change and the need for sustainable energy, education plays a vital role in understanding energy systems. Energy literacy helps people make informed choices about energy use and encourages communities to shift to renewable sources. Incorporating energy literacy into higher education is essential for training future leaders in sustainable development. By integrating energy and sustainability topics into university courses, we can nurture a generation of well-informed citizens ready to tackle global sustainability challenges. Additionally, knowledge transfer is vital for connecting academic research with real-world applications. This means fostering collaboration between universities, industry, and policymakers to make the latest energy advancements accessible and actionable. Such efforts can significantly boost progress toward SDGs like affordable and clean energy (SDG 7) and climate action (SDG 13).

In the era of Society 5.0 and the SDGs, empowering tertiary students with energy transition (ET) knowledge is crucial. Naemzia and Kaman (2025) emphasize that a multifaceted approach is essential to achieve this, encompassing the integration of SDG knowledge into university education, the adoption of next-generation learning models leveraging smart technologies, and the active involvement of students in real-world projects. By

Carefully planning university curricula and enforcing educational policies, institutions can lay the groundwork for a comprehensive understanding of energy transition dynamics. This not only enhances energy literacy but also plays a pivotal role in equipping students to contribute effectively to achieving the SDGs. Furthermore, Menício et al. (2024) explores the role of knowledge sharing in achieving the SDGs and advancing sustainability. It is evident that knowledge sharing significantly and positively impacts the SDGs and sustainability, particularly focusing on SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation, and Infrastructure). The findings suggest that practices of knowledge sharing enhance organizational sustainability. By replicating some of the studies reviewed in various regions or countries, the research proposes that we can address generalization challenges and support the adaptation and implementation of effective knowledge-sharing practices. Previous study by Gladwin and Ellis (2023) recognizing the direct link between the global energy supply and consumption to the climate crisis, this article illustrates how energy literacy can provide environmental and sustainability education with innovative approaches to addressing the energy transition. Martins et al. (2020) emphasized the energy literacy is increasingly recognized as a vital tool for encouraging citizens to adopt sustainable energy consumption habits. This growing interest among researchers and policymakers highlights its importance. Energy literacy goes beyond mere knowledge; it encompasses cognitive, affective, and behavioral dimensions, equipping individuals to make well-informed decisions about energy use. By fostering an understanding of energy systems and their impacts, energy literacy empowers people to contribute to a more sustainable future.

Therefore, energy literacy serves as a crucial element in bridging the gap between knowledge and action, significantly impacting the pursuit of SDGs. By encompassing cognitive, affective, and behavioral dimensions, ET empowers individuals to make informed decisions about energy use, fostering sustainable consumption habits. This, in turn, facilitates knowledge transfer, a process where insights and innovations in energy technology and policy are shared across various sectors, including education, industry, and government. Such transfer is vital for achieving SDGs like Affordable and Clean Energy (SDG 7) and Climate Action (SDG 13), as it encourages the adoption of renewable energy solutions and the implementation of environmentally conscious policies. Moreover, energy-literate citizens are better equipped to participate in collaborative projects and advocate for sustainable practices, contributing to broader SDG goals such as sustainable cities and communities (SDG 11) and responsible consumption and production (SDG 12). By fostering a culture of informed decision-making and active participation, energy literacy and knowledge transfer together drive meaningful progress toward global sustainability targets

## 2. THEORETICAL FRAMEWORK

The study of energy literacy and knowledge transfer in higher education requires grounding in well-established theoretical frameworks that capture the complexity of student learning, institutional change, and sustainable development. This paper draws on four (4) key perspectives: Energy Literacy Models, Knowledge Transfer Theory, Transformative Learning Theory, and Systems Thinking and Complexity Theory. Together, these frameworks provide a multidimensional lens for analyzing the integration of EL and KT, obstacles and pathways to advancing energy literacy in higher education institutions (HEIs) towards SDGs.

### 2.1 Energy Literacy Models

Energy literacy forms the conceptual backbone of this study, highlighting the knowledge, attitudes, and behaviors necessary for students to engage with energy challenges effectively. Gladwin and Ellis (2019) emphasize three dimensions of energy literacy, namely epistemological, ontological, and application dimensions, which extend beyond scientific facts to include contextual and practical applications of energy systems. Cotton et al. (2015) further elaborate through the 4Es model, which situates energy literacy as a behavioral and institutional responsibility by enabling, engaging, exemplifying, and encouraging students. In addition, Lowan-Trudeau and Fowler (2021) propose a critical energy literacy framework that integrates decolonial and Indigenous perspectives, ensuring that energy literacy encompasses issues of equity, culture, and power dynamics.

### 2.2 Knowledge Transfer Theory

Knowledge transfer in higher education is central to embedding energy literacy both within curricula and beyond. Argote and Ingram (2000) define knowledge transfer as both tacit and explicit, occurring through individual, peer, and institutional mechanisms. Kuglitsch (2019) emphasizes teaching for transfer, which enables students to apply knowledge across multiple contexts, while Harmon and Gray (2018) highlight forward-looking transfer, which prepares learners to adapt energy concepts to future professional and societal challenges. These approaches underscore the importance of ensuring that energy-related knowledge acquired in academic settings translates into practical competencies that directly support Sustainable Development Goals such as climate action and sustainable cities.

### 2.3 Transformative Learning Theory

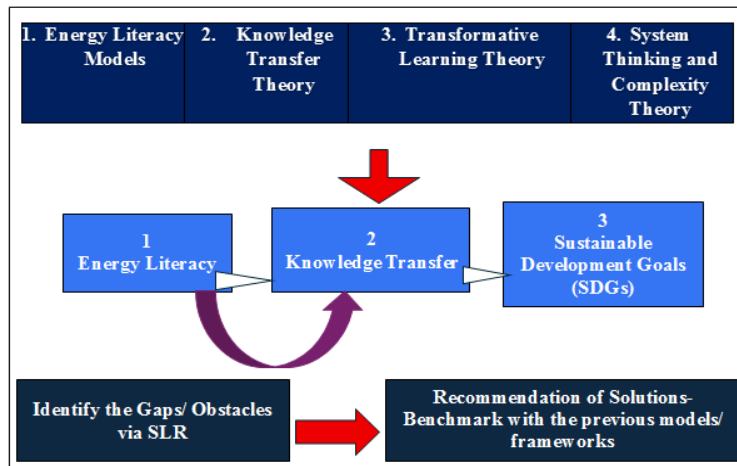
Transformative learning, as articulated by Mezirow (1991), provides a strong foundation for understanding how students can progress from awareness to action. Through disorienting dilemmas, critical reflection, and dialogue, learners are encouraged to re-examine their assumptions about energy and sustainability. Sterling (2011) extends this into the transformative sustainability learning model, which emphasizes three levels of learning: acquiring information about sustainability issues, understanding systemic relationships, and transforming worldviews and values. These dimensions are crucial for cultivating energy literacy that not only informs but also

reshapes students' values, leading to behavioral and cultural change that is essential for advancing the SDGs.

### 2.4 Systems Thinking and Complexity Theory

Energy issues are embedded within complex socio-ecological systems. Systems thinking, as proposed by Senge (1990), provides an approach to view energy as part of interconnected feedback loops involving technology, society, and the environment. Morrison (2008) expands

this through complexity theory, which highlights concepts such as emergence, adaptation, and non-linearity in educational change. Applying these perspectives allows higher education institutions to design curricula and initiatives that account for the interconnected nature of energy, sustainability, and development. This approach also supports more adaptive and holistic responses to global challenges.



**Figure 1:** Conceptual framework for energy literacy (EL) and knowledge transfer (KT) among higher institutions (HEIs) towards SDG.

*Source:* Authors

### 3.1 Research Methodology

This study adopted a Systematic Literature Review (SLR) to synthesize existing research on energy literacy (EL) and knowledge transfer (KT) within higher education institutions (HEIs). The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (Moher et al., 2009), a widely recognized guideline for conducting systematic reviews. This study seeks to address three thematic areas drawn from the existing literature:

1. How knowledge transfer (KT) through energy literacy (EL) in higher education institutions (HEIs) is described.
2. How EL and KT together create a synergistic effect in contributing to the achievement of the Sustainable Development Goals (SDGs).

3. What obstacles exist in establishing EL and KT in HEIs.

To address the research question, a comprehensive search strategy was implemented using the **Google Scholar database**. Keywords were systematically selected to ensure the retrieval of relevant studies, with the focus placed on *energy literacy, knowledge transfer, Knowledge, higher education, and SDGs*. The combination of search terms included “*Energy Literacy*”, “*Knowledge Transfer*”, “*Higher Education*”. Articles were picked up manually and removed articles that were non-English, not in their final publication stage, published before 2015, or not journal articles. The review covered literature published between **2015 and 2025**, with the final database search conducted on **20 August 2025**. The selection process applied predefined inclusion and exclusion criteria to ensure the relevance and quality of the studies reviewed. These criteria are outlined in Table 2.

**Table 1:** Inclusion and Exclusion Criteria

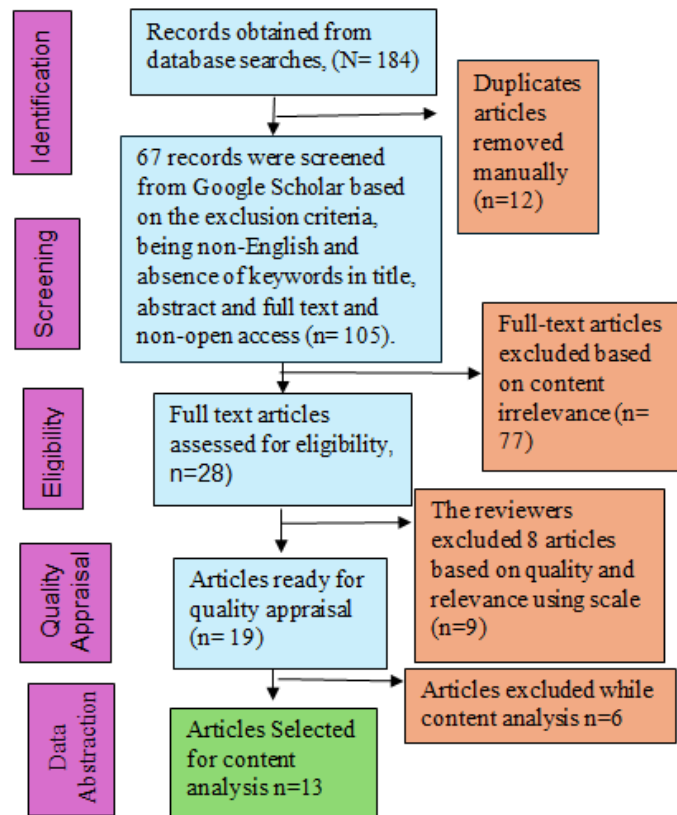
Criteria	Inclusion	Exclusion
Timeline	2015–2025	<2014
Language	English	Non-English
Document type	Journal articles, conference papers	Book chapters, book series, books
Content	Articles related to energy literacy and knowledge transfer	Articles not related to these themes

**RESEARCH PAPER**

Finally, all studies meeting the inclusion criteria were subjected to multiple stages of screening and analysis. A thematic analysis approach was applied to identify patterns and insights across the selected literature. The analysis was organized around three core themes:

1. **Discussing Energy Literacy and Knowledge Transfer** – examining how existing studies define and describe EL and KT in HEIs.

2. **Barriers and Obstacles** – identifying challenges highlighted in the literature regarding the establishment of KT through EL in HEIs.
3. **Linkages to SDGs** – exploring how EL and KT initiatives in higher education contribute to the achievement of SDG objectives.



**Figure 2:** The overview of SLR process. Source: adapted from Moher et al. (2009)

This systematic and thematic approach ensured a comprehensive understanding of the current state of research, the gaps that remain, and the potential pathways for advancing EL and KT to support sustainable development in higher education. The overview of SLR processes are depicted in the above figure 2.

**4. RESULTS AND DISCUSSIONS**

Among the selected study four (4) are review paper (Hu and Yang, 2024; Munaro and John, 2024; Santillán and Cedano, 2023; Majid, Osman and Yee, 2025), twelve (12) are empirical paper. Whereas three (2) studies (Reinhardt et al., 2020; Hu and Yang, 2024; and Grigorescu et al., 2022) addressed the term “knowledge transfer” and other Nine (9) studies (Mehmood et al., 2022; Munaro and John,

2024; Cotton et al., 2015; Santillán and Cedano, 2023; Majid, Osman and Yee, 2025; Rohmatulloh et al., 2021; Akitsu and Ishihara, 2018 and Lee, Nguyen and Sung, 2022; Hamidi Razi, Ranjpour and Motafakker Azad, 2021; Ji et al. 2023) addressed knowledge as a component of EL. Articles considered EL for high school (Akitsu and Ishihara, 2018; Lee, Nguyen and Sung, 2022; Ji et al. 2023); whereas considered higher education (Reinhardt et al., 2020; Hu and Yang, 2024; Munaro and John, 2024; Cotton et al., 2015), other articles discussed EL and Knowledge from other stakeholders perspectives. However, the article selected for content analysis are depicted in the following figure 3 based on their publication year and publishing countries. Besides that, table 2. shows the article included in the study.

\*Author for Correspondence: sidra@uniten.edu.my

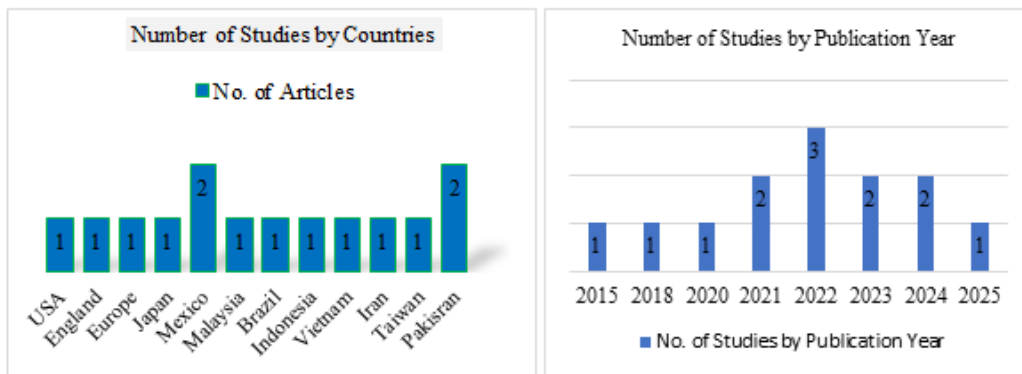


Figure 2. shows the number of studies based on the countries of publication and year of publication

Table 2:

No.	Title	Author(s)
1	A knowledge management approach to promote an energy culture in higher Education	Reinhardt et al. (2020)
2	Synergy Analysis of Knowledge Transfer for the Energy Sector within the Framework of Sustainable Development of the European Countries	Grigorescu et al. (2022).
3	Qualitative mapping of barriers to the renewables' development against energy literacy dimensions: A case study of Pakistan	Mehmood et al. (2022).
4	Interactive Cycles between Energy Education and Energy Preferences: A Literature Review on Empirical Evidence	Hu and Yang (2024)
5	Energy Efficiency in the Higher Education Institutions: A Review of Actions and Their Contribution to Sustainable Development	Munaro and John (2024).
6	Developing students' energy literacy in higher education	Cotton et al. (2015).
7	Energy Literacy: A Systematic Review of Scientific Literature	Santillán and Cedano (2023).
8	Integrating energy literacy into science education: a comprehensive systematic review	Majid, Osman and Yee, (2025)
9	Energy Literacy and Education: The Viewpoint of Stakeholders to Promote Energy Literacy in Education	Rohmatulloh et al. (2021).
10	An Integrated Model Approach: Exploring the Energy Literacy and Values of Lower Secondary Students in Japan	Akitsu and Ishihara, (2018)
11	Energy literacy of high school students in Vietnam and determinants of their energy-saving behavior.	Lee, Nguyen and Sung, (2022).
12	Energy Literacy and Energy-related Financial Literacy in Iran: Case of Northwestern Academic Community	Hamidi Razi, Ranjpour and Motafakker Azad, (2021).
13	A Learning Ecology Perspective of Energy Literacy among Youth: A Case Study from Alabama High Schools	Ji et al. (2023)

The finding of the SLR and thematic analysis as based on research objectives, existing studies discussion about EL and KT in higher education institutions, and higher educational institutions, and alignment of EL and KT to achieve SDG goals and the probable challenge and barriers described in the existing studies are described in the following sub sections 3.1, 3.2 and 3.3.

#### 4.1 Energy Literacy and Knowledge Transfer (KT) in Higher Education Institutions (HEIS)

While defining EL, previous studies defined EL as an integrated capacity encompassing knowledge, values, and skills that enables individuals to understand energy systems, evaluate energy-related information, make informed choices, communicate effectively, and take

responsible action in energy contexts. Energy literacy encompasses three key dimensions: knowledge (cognitive), which involves understanding energy concepts, sources, usage, and impacts; attitudes (affective), which reflect the values and beliefs individuals hold about energy, including awareness of its environmental and societal implications; and behavior (behavioral), which refers to actively engaging in energy-related actions such as conservation, informed decision-making, and advocacy (Cotton et al., 2015). While discussing knowledge transfer (KT) in relation to energy sector, it is defined as the process of sharing, disseminating, and applying knowledge, skills, and innovation between universities, research institutions, businesses, and policymakers to improve the energy sector's efficiency, sustainability, and innovation capacity (Grigorescu et al., 2022). It goes beyond one-directional communication, emphasizing synergistic interaction among stakeholders (e.g., academia, industry, government, and society) to achieve collective goals such as advancing renewable energy adoption, enhancing energy efficiency, and meeting sustainable development targets (Grigorescu et al., 2022). They also highlighted that KT in the energy sector is not merely about technology diffusion but also about building cooperation platforms, fostering innovation ecosystems, and creating synergies across economic, environmental, and social domains to ensure long-term sustainability.

Reinhardt et al. (2020) suggested a knowledge management approach for higher education institutes, where they suggested that effective educational strategies and materials are essential to promote knowledge transfer that fosters positive energy use behavior while minimizing the influence of previously inherited misconceptions.

Among the reviewed paper, Grigorescu et al., (2022) and Reinhardt et al. (2020) described EL from this modern terminology KT perspectives. However, they discussed KT among all the stakeholders in energy sector rather than focusing on HEIs only, whereas other paper discussed knowledge as a component of EL along with other affective and behavioural components.

Mehmood, et al. (2022), Qualitative mapped the barriers to the renewables' development against EL dimensions through a case study in Pakistan. They suggested Energy literacy should be a part of the education curriculum of every field with the following priority focus of domains: affective >cognitive >conative. This EL education can include the basic knowledge on various energy resources, energy consumption and their impact on environmental sustainability. Along with the technical knowledge, the proportion of curriculum accounts for affective and conative domains of literacy should be heightened and be compulsory as attitude is more important than knowledge sub-dimension. Thus, the awareness of energy savings and environmental protection should be gradually developed through the curriculum among the public to promote the transformation of behavior towards a green lifestyle. They also addressed EL can help to achieve SDG 4 and SDG 7. However, they addressed the term knowledge instead of KT, and the study is also not related to HEIs.

Hu and Yang (2024) highlighted in the literature review paper that energy education is a process which generates an interactive cycle between learning and preference formation. Effective transfer not only changes behaviors and preferences but also generates demand for more refined knowledge and innovation in the energy sector. From this perspective, energy education operates on two levels: building energy literacy among the public and preparing professionals with specialized expertise. While literacy programs shape awareness and behavior, professional training ensures the circulation of advanced knowledge into practice, driving sustainable energy transitions.

Munaro and John (2024) addressed that HEIs such as universities as a major energy consumers, can play a crucial role in promoting sustainable and renewable energy practices. They suggested a more integrated approach—combining technology, stakeholder commitment, and government support—is essential to enhance campus sustainability. However, KT is not directly addressed here.

Cotton et al. (2015) showed that higher education enhances students' energy literacy (EL) through both formal and informal learning, with universities acting as important platforms for spreading knowledge. Their study found that student understanding was influenced not only by lectures but also by institutional culture and campus life. To strengthen KT, they proposed the 4Es model—Enable, Engage, Exemplify, and Encourage—highlighting that effective energy education transfers values and behaviors as well as knowledge.

Santillán and Cedano (2023) conducted a systematic review of 138 studies on energy literacy, defining it as understanding how energy is generated, transported, stored, distributed, and used, alongside awareness of its social and environmental impacts. Their findings show that most research focuses on evaluating energy literacy among students, as well as developing and testing tools to enhance it. The review highlights gaps in linking energy literacy with efficient energy use. However, the findings also addressed the term knowledge only rather than KT.

In a comprehensive review, Majid et al. (2024) revealed that interdisciplinary approaches, hands-on experiments, and innovative tools such as VR-AR enhance students' understanding and attitudes toward energy, especially renewable energy. Project-based learning and STEM integration further strengthen problem-solving skills and creativity. They addressed high cognitive load in interdisciplinary learning and the demand for continuous teacher training as challenges. The review emphasizes the need for standardized curricula and sustained professional development to better support educators. However, the exact term KT is absent here.

The study by Rohmatulloh et al. (2021) examines how stakeholders in Indonesian Islamic boarding schools promote EL through education. Energy concepts are integrated into both environmental and religious curricula, providing a structured knowledge transfer (KT) pathway

to students. The research highlights the importance of engaging multiple actors—students, teachers, parents, and community leaders—to enhance understanding, attitudes, and behaviors related to energy use. However, sustaining behavioral change remains challenging, emphasizing that effective KT requires consistent reinforcement and alignment with broader policy goals. However, this study is not related to HEIs and the term KT is not directly addressed.

Akitsu and Ishihara (2018) explored EL among lower secondary students in Japan using an integrated model combining the Theory of Planned Behavior and Value-Belief-Norm Theory. It shows that transferring knowledge, values, and norms effectively shapes students' awareness, attitudes, and energy-saving behaviors. Factors such as scientific literacy, critical thinking, environmental worldview, and family discussions strengthen this knowledge transfer process. This study is also not related to HEIs and the term KT is not directly addressed.

The study by Lee, Nguyen, and Sung (2022) investigates the energy literacy of high school students in Vietnam and identifies factors influencing their energy-saving behavior. The research reveals that while students possess relatively high attitudes, values, intentions, and behaviors toward energy conservation, their actual energy knowledge tends to be low. Notably, energy knowledge does not directly impact energy-saving intentions or behaviors; instead, values and attitudes mediate this relationship. Additionally, public school students reported more energy-saving actions than their private school counterparts, and mass media emerged as the primary source of their energy knowledge.

Lee et al. (2022) found that general energy knowledge alone did not significantly influence energy-saving behaviors of high school students; instead, self-efficacy, attitudes, and pro-environmental values were more impactful. From a knowledge transfer (KT) perspective, this indicates that transferring information alone is insufficient to change behaviors. Effective KT should therefore target not only knowledge but also the emotional, attitudinal, and value-based dimensions that drive sustainable energy practices. This study is also not related to HEIs and knowledge is considered as a component of EL.

Ranjpour, and Azad (2021) found that higher economic and financial literacy among university staff in Iran is positively associated with improved energy literacy and greater awareness of energy costs, with factors like larger housing area and older age also contributing. The study highlights that effective energy education should combine technical energy knowledge with economic and financial

understanding to help individuals make informed decisions. Integrating these domains into energy programs will bridge knowledge acquisition and practical application to promote sustainable energy behaviors. However, the term KT is not directly mentioned here.

The study by Ji et al. (2023) investigates factors influencing energy literacy among high school students in Alabama, employing a learning ecology perspective. Findings indicate that participation in school-based clean energy programs, engagement with virtual information sources, and interactions with peers and family positively impact students' energy-related information searches, attitudes, and behaviors. Additionally, pre-existing STEM interests and family relationships significantly contribute to energy literacy development. The research underscores the importance of integrating these diverse learning factors into educational programs to create a synergistic learning ecosystem that fosters energy literacy among youth. However, this study also hasn't exactly addressed KT and is not related to HEIs.

Hence, from the reviewed articles it is clearly visible although there are abundant of studies addressing EL in education section, a little focus is given of higher education sector. Besides that, 'knowledge' is considered as the cognitive factor as a component under EL framework, which shows there is a research gap to view EL in the frame of emerging KT perspectives to get the synergic benefit from it.

#### 4.2 Integration of EL and KT to Get Synergic Effect in Attaining SDGs

Higher Education Institutions (HEIs) have the potentials to play role in advancing sustainable energy transitions and achieving Sustainable Development Goals (SDGs) 2030 (Daoudi, 2024). University campuses can be transformed to a small-scale ecosystem, from where experimental testing and case studies for urban sustainability practices can be done (Munaro & John, 2024). In higher education settings, knowledge transfer (KT) provides the opportunities for structured teaching, training, and policy frameworks in order to develop an energy-conscious culture, while energy literacy (EL) develops students' awareness, attitudes, and problem-solving skills for sustainable practices (Daoudi, 2024; Mehmood, Lin, Zhang, Lee & Ren, 2022). Together, they can strengthen SDG 4 (Quality Education) by integrating sustainability into curricula, support SDG 7 (Affordable and Clean Energy) SDG 8 (Decent Work and Economic Growth) by preparing students with vocational skills and innovative capacities. This synergy enables HEIs to act as the drivers of sustainable development by aligning knowledge dissemination with energy literacy-driven behavioral change.

**Table 3:** Alignment of EL and KT with sustainable development (SDG) goals

SDG Goal	Role of Knowledge Transfer (KT)	Role of Energy Literacy (EL)
SDG 4: Quality	Provides structured teaching, training,	Inculcates awareness, critical thinking,

Education	and policy frameworks that advocates sustainability into higher education.	and problem-solving skills for sustainable practices among students
SDG 7: Affordable and Clean Energy	Channels technical and policy knowledge on energy efficiency and renewable systems.	Empowers students to comprehend and champion sustainable energy choices.
SDG 8: Decent Work and Economic Growth	Opens scopes for vocational trainings that link education with innovation and entrepreneurship.	Equips future leaders with skills to engage in green jobs and sustainable enterprises.

### 4.3 Challenges/ barriers to Integrating Energy Literacy (EL) and Knowledge Transfer (KT) in Higher Education Institutions (HEIs):

Integrating Energy Literacy (EL) and Knowledge Transfer (KT) into higher education is essential for equipping students with the knowledge, skills, and attitudes necessary to adopt sustainable energy practices. However, several challenges hinder the effective incorporation of EL and KT into curricula, limiting both student learning and institutional impact. The challenges that are addressed in the reviewed studies are described below.

1. Institutional unwillingness and lack of support: Munaro and John (2024) identified that limited participation and support from university authorities is a major obstacle to incorporating EL and KT in higher education institutions (HEIs). They highlighted that the lack of clear policy directions and reluctance to develop eco-friendly infrastructures further hinders progress. In addition, the absence of sustainability performance reporting within HEIs also acts as a barrier.
2. Limited knowledge and awareness among students: Cotton et al. (2015) noted that students and the general public often have insufficient knowledge and awareness regarding the importance of EL. As a result, the topic is frequently neglected and given low priority by regulatory authorities.
3. Discipline-specific curriculum focus: EL is primarily addressed within science-oriented programs, with minimal attention in other disciplines. Despite its strong connection to science, EL is relevant across all academic fields. Cotton et al. (2015) argue that universities should integrate EL into their core curricula in order to enhance consciousness among future leaders and make them responsible towards the sustainability issues.
4. Neglect of attitudinal and behavioral dimensions: The review by Majid, Osman, and Yee (2025) emphasizes that most initiatives focus on knowledge acquisition but often overlook attitudinal and behavioral aspects that are essential for fostering sustainable practices.
5. Teacher preparedness and fragmented curriculum integration: Additional challenges include limited teacher readiness, fragmented incorporation of EL into curricula, and the absence of comprehensive frameworks, high load of interdisciplinary courses (Majid, Osman, and Yee, 2025).

6. Insufficient focus on practical applications and values in KT: From a knowledge transfer perspective, addressing these barriers requires going beyond technical content to include values, attitudes, and practical applications. This ensures that EL not only informs students but also equips them to adopt sustainable energy practices in real-life contexts ((Majid, Osman, and Yee, 2025).)

Overall, the integration of EL and KT in higher education faces multiple institutional, curricular, and pedagogical challenges. Overcoming these barriers requires comprehensive strategies that address policy support, curriculum design, teacher readiness, and practical application, alongside fostering both cognitive and behavioral engagement among students. Only through such a holistic approach can EL effectively contribute to sustainable energy practices and long-term societal impact.

### 5.0 RECOMMENDATIONS AND WAY FORWARD

Overcoming the challenges of integrating Energy Literacy (EL) and Knowledge Transfer (KT) in Higher Education Institutions (HEIs) necessitates a strategic and multifaceted approach.

Firstly, tackling institutional unwillingness and lack of support is crucial. This can be accomplished by developing clear educational policy directions and advocating for the establishment of eco-friendly infrastructures. Encouraging university authorities to commit to sustainability performance reporting will also foster accountability and progress. This approach aligns with Systems Thinking and Complexity Theory as proposed by Senge (1990) and Morrison (2008), which emphasize emergence, adaptation, and non-linearity in educational change. By applying these perspectives, higher education institutions can design curricula and initiatives that account for the interconnected nature of energy, sustainability, and development, supporting more adaptive and holistic responses to global challenges.

Secondly, the neglect of attitudinal and behavioral dimensions can be mitigated by designing initiatives that focus on these aspects alongside knowledge acquisition. Experiential learning opportunities and projects that encourage sustainable practices can foster a more comprehensive understanding of EL. Moreover, to combat limited knowledge and awareness among students, universities should implement awareness campaigns and educational workshops that underscore the importance of EL. Prioritizing this topic encourages both students and related stakeholders within community authorities to recognize its significance. To ensure practical applications and values are emphasized in KT, curricula should

incorporate real-life scenarios that allow students to apply their knowledge in meaningful contexts. Partnering with industry and community organizations can provide hands-on experiences that highlight the values and attitudes necessary for sustainable energy practices. This is supported by Transformative Learning Theory, as articulated by Mezirow (1991) and Sterling (2011), which extends into the transformative sustainability learning model. This model emphasizes three levels of learning: acquiring information about sustainability issues, understanding systemic relationships, and transforming worldviews and values. These dimensions are crucial for cultivating energy literacy that not only informs but also reshapes students' values, leading to behavioral and cultural change essential for advancing the Sustainable Development Goals (SDGs). Harmon and Gray (2018) further support this under Knowledge Transfer Theory, highlighting forward-looking transfer, which prepares learners to adapt energy concepts to future professional and societal challenges.

Lastly, to address the discipline-specific curriculum focus, HEIs should integrate EL into core curricula across all academic fields, not just science-oriented programs. This integration will ensure that all students, regardless of their major, receive comprehensive education in energy literacy. Enhancing teacher preparedness and addressing fragmented curriculum integration is essential. Providing educators with professional development and resources will equip them to effectively teach EL. Additionally, creating comprehensive frameworks and reducing the overload of interdisciplinary courses will streamline curriculum integration. This aligns with Energy Literacy Models by Gladwin and Ellis (2019), which emphasize three dimensions of energy literacy: epistemological, ontological, and application dimensions. These extend beyond scientific facts to include contextual and practical applications of energy systems. The 4Es model by Cotton et al. (2015) situates energy literacy as a behavioral and institutional responsibility by enabling, engaging, exemplifying, and encouraging students.

## 6.0 FUTURE RESEARCH

Future research in integrating Energy Literacy (EL) and Knowledge Transfer (KT) into higher education should focus on several key areas to address existing challenges effectively. First, investigating strategies to increase institutional support and develop clear policy directions will be crucial in overcoming administrative barriers. Research could explore models for incorporating sustainability performance metrics into HEIs, providing a framework for accountability and progress. Additionally, studies should examine innovative approaches to raising student and public awareness about the significance of EL, potentially through targeted campaigns or curriculum reforms that prioritize EL across disciplines. Interdisciplinary research can also evaluate the impact of integrating EL into non-science programs, ensuring a holistic educational approach. Moreover, examining the attitudinal and behavioral dimensions of EL will help identify methods to cultivate sustainable practices among

students. Teacher preparedness and curriculum integration present another rich area for exploration, with research needed on effective training programs and comprehensive frameworks that facilitate seamless inclusion of EL into existing curricula. Finally, investigating practical applications of EL in real-world contexts can provide insights into how values and attitudes can be effectively transferred, equipping students to implement sustainable energy practices in everyday life.

## 7.0 CONCLUSION

The exploration of integrating Energy Literacy (EL) and Knowledge Transfer (KT) in higher education reveals a promising pathway to enhance sustainable development. While the current focus on EL in education is notable, there is a clear gap in the higher education sector that needs attention. By embedding EL and KT into SDGs vision, HEIs can be transformed into hubs for advancing sustainable energy transitions, ultimately supporting the achievement of the Sustainable Development Goals (SDGs) by 2030.

HEIs have the unique capacity to act as microcosms for experimental testing and case studies on urban sustainability. Through structured teaching and education policy frameworks, KT helps cultivate an energy-conscious culture, while EL builds students' awareness, attitudes, and problem-solving skills. This synergy not only strengthens SDG 4 (Quality Education) by integrating sustainability into curricula but also supports SDGs 7 (Affordable and Clean Energy) and 8 (Decent Work and Economic Growth) by preparing students with vocational skills and innovative capacities.

The systematic literature review conducted in this research highlights key knowledge gaps, especially related to the SDGs. The energy literacy model fosters deep understanding and practical application, while KT emphasizes the importance of cross-contextual knowledge application. Together, they prepare students for future challenges, supporting broader SDGs like climate action and sustainable cities. The application of Transformative Learning Theory, Systems Thinking, and Complexity Theory enhances this approach by emphasizing action-oriented learning and the understanding of socio-ecological systems.

Ultimately, this study underscores the critical need for stakeholders to prioritize EL and KT in higher education. By doing so, they can guide HEIs towards playing a pivotal role in sustainable development, aligning knowledge dissemination with behavioral change. This research offers strategic insights for HEI management, researchers, policymakers, and students, providing a roadmap for integrating energy literacy with SDGs, identifying research gaps, informing policy, and empowering students to address real-world challenges while fostering leadership in sustainability.

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