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Fostering Workforce Readiness for the Green Hydrogen Economy through People-Centric Training Programs

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Abstract:- One of the most important ways to cut carbon emissions and fight climate change is to switch to green hydrogen, a clean energy source made by electrolysis using renewable resources. A significant obstacle to this shift, nevertheless, is the lack of a trained labor force that can handle the complexity of hydrogen technologies. In addition to addressing technical skills, this study highlights the importance of a people-centric approach to workforce training that promotes flexibility, creativity, and lifelong learning. Organizations can bridge the skills gap and promote sustainable growth in the green hydrogen economy by giving individual learning needs and career development priority. This study examines the important connections between training accessibility, skills acquisition, institutional support, and workforce preparation using both theoretical and empirical data. The findings reveal that fostering familiarity with green hydrogen concepts significantly enhances skill acquisition and readiness to transition into this evolving sector. Furthermore, the study identifies major barriers to training—namely cost, inaccessibility, and time constraints—and suggests that hybrid and online training models, supported by strong institutional partnerships, offer the most effective solutions. This paper concludes by proposing a people-centric training framework that can empower the workforce to meet the demands of the green hydrogen economy, ultimately contributing to a just and efficient energy transition.

***Keywords**:- Green Hydrogen, Workforce Training, People-Centric Approach, Skills Gap, Energy Transition, Institutional Support, Renewable Energy, Hybrid Training, Skills Acquisition, Green Economy.*

I. INTRODUCTION

A. Background

Over the years, countries around the world have sought to reduce carbon emissions to address the risks posed by climate change and meet their commitments to the Paris Agreement ratified by 196 parties in 2015. Accordingly, green hydrogen, produced through electrolysis powered by renewable energy sources such as wind, solar, or hydropower, is emerging as a pivotal element in the global transition to sustainable energy systems. This process involves splitting water (H_2O) into hydrogen (H_2) and oxygen (O_2) with zero carbon emissions, thereby supporting decarbonization efforts and promoting environmental sustainability (International Energy Agency, 2021). Unlike gray and blue hydrogen, which are associated with greenhouse gas emissions, green hydrogen is entirely emission-free throughout its lifecycle, from production to consumption, highlighting its potential as a transformative energy source (IRENA, 2020). The growing emphasis on green hydrogen aligns with the urgent need to achieve net-zero emissions and combat climate change, particularly in sectors challenging to decarbonize with electricity alone, such as heavy industry, shipping, aviation, and long-distance transportation (European Commission, 2020).

A crucial limitation to this, however, is the technical challenges associated with green hydrogen production, the shortage of a workforce well equipped and skilled in all phases of the operations of green hydrogen production. Hence, there is a need to emphasize the importance of cultivating a skilled workforce capable of driving innovation and ensuring safety in this rapidly evolving sector. It is without doubt therefore that the successful deployment of green hydrogen technologies hinges on a people-centric approach to workforce development, which prioritizes individual skill acquisition, career aspirations, and well-being. For instance, Germany’s ambitious plans to adopt green hydrogen in its steel production have underscored the urgent need for a skilled workforce ready to support this transition. Likewise, as many countries transition to green hydrogen, the challenge of a skilled workforce to drive the economy becomes evident. The United States's green hydrogen sector necessitates comprehensive training and upskilling programs, but the scope and depth of requirements remain unexplored.

B. Problem Statement

The green hydrogen industry has many labor obstacles, including a severe lack of qualified workers who can manage the complexity of hydrogen technologies, despite its benefits to the environment. The industry's capacity to grow has been directly hampered by this shortfall, which has resulted in longer project deadlines and more operating expenses. The industry's potential to make a significant contribution to decarbonization targets is threatened by employment gaps stemming from the sector's rapid expansion outpacing the supply of competent people. For instance, new data indicates that the increase of global green hydrogen capacity is being slowed by 20% due to a shortage of skilled labor in critical fields such as electrolysis and hydrogen storage (World Energy Council, 2023).

The current energy workforce often lacks the diverse skill sets required for green hydrogen applications, as many workers are primarily trained in traditional fossil fuel technologies (Griffiths et al., 2023). This discrepancy limits innovation and operational efficiency by generating additional bottlenecks. These difficulties are made worse by the lack of industry-wide training and certification programs, which prohibit employees from obtaining the credentials required to move into positions involving green hydrogen. The role of key stakeholders, including educational institutions, industry leaders, and policymakers, in addressing these workforce shortages is crucial. The legal framework and financing sources for training programs are mostly determined by policymakers, and educational institutions must create specific curricula that meet the rapidly changing needs of the hydrogen economy. The green hydrogen sector runs the risk of not realizing its transformative potential in the absence of active participation.

C. Objective and Scope

The transition to a green hydrogen economy requires a workforce that is not only technically proficient but also adaptable to the sector's unique demands. A key obstacle lies in the lack of clearly defined career pathways within the green hydrogen industry, which can hinder employee recruitment and retention (World Energy Council, 2023). The educational and training programs necessary for workforce development are still in their infancy, requiring significant investment in specialized training tailored to hydrogen production, safety protocols, and maintenance procedures. As noted by Hydrogen Council (2021), this investment is crucial for establishing a skilled workforce capable of meeting the industry's needs while ensuring rapid access to qualified personnel.

Implementing a people-centric approach in workforce training programs is essential for effectively bridging the skills gap in the green hydrogen sector. By focusing on individual learning needs and career aspirations, organizations can develop targeted training initiatives that enhance job satisfaction, employee engagement, and retention in an industry where competition for skilled workers is fierce (World Energy Council, 2023). This approach not only fosters a culture of continuous learning but also empowers employees by valuing their contributions to the organization, ultimately driving innovation within the field (Griffiths et al., 2023).

D. Research Questions

To explore the impact of a people-centric approach on workforce training for the green hydrogen transition, the following research questions will guide this study:

- How does familiarity with green hydrogen influence readiness to transition into the green hydrogen industry, and what role do skills in green energy and institutional support play in this process?
- What are the key barriers to accessing training for the green hydrogen transition, and how do different training modes and industry sectors influence these barriers?
- How does the implementation of a people-centric approach in workforce training programs influence employee skill acquisition in the green hydrogen industry?

E. Justification

Given the sophistry and safety-critical nature of hydrogen technologies, a people-centric approach reinforces a robust safety culture by emphasizing personal accountability and the continuous improvement of safety protocols (Rigas & Amyotte, 2013). Additionally, as the energy sector transitions from fossil fuels to renewable technologies, comprehensive training programs tailored to this shift are vital. Collaborative policy support and active industry engagement are necessary to facilitate a smooth transition for workers impacted by the move from traditional energy sources to green hydrogen solutions (World Economic Forum, 2020).

While green hydrogen offers a promising pathway for achieving decarbonization and sustainability, its successful integration into the energy landscape is contingent upon a well-prepared and skilled workforce. The implementation of a people-centric approach in workforce training programs is crucial for enhancing employee skill acquisition, fostering engagement, ensuring readiness for sector transitions, and driving innovation in the green hydrogen economy. The subsequent sections of this article will explore how this approach can effectively address the existing skills gap and prepare the workforce for the challenges and opportunities presented by the green hydrogen sector.

II. LITERATURE REVIEW

A. Conceptual Review

➢ *Green Hydrogen Industry*

Unlike its gray or blue cousins, green hydrogen has no direct CO_2 emissions during manufacturing, which makes it very appealing to nations with ambitious climate goals. Green hydrogen is positioned as a vital enabler of a low-carbon future because electrolysis, the process by which water is split into hydrogen and oxygen using energy, can be fueled by renewable sources like wind or solar. Many consider it a key component of a sustainable global energy system, and governments, researchers, and industry are all keeping a careful eye on its potential (International Energy Agency, 2019).

Green hydrogen is becoming more popular in the US as a result of focused government initiatives and wise financial decisions. The ambitious goal of producing 10 million metric tons of clean hydrogen yearly by 2030 was established by the U.S. Department of Energy's National Clean Hydrogen Strategy and Roadmap, which was presented in 2023. This endeavor is further supported by the Inflation Reduction Act (IRA), which provides significant tax credits for hydrogen generation, increasing its economic viability. For example, depending on its carbon intensity, the Clean Hydrogen Production Tax Credit offered by the IRA can provide up to $3 per kilogram of hydrogen.

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In addition, the establishment of Regional Clean Hydrogen Hubs is assisting in the expansion of the infrastructure required to support hydrogen's increasing contribution to the American energy mix. Through the integration of networks for production, distribution, and consumption, these centers are establishing sustainable hydrogen ecosystems throughout the nation. Projects like Southern Company's hydrogen-blending experiments and Florida Power & Light's 20 MW hydrogen plant serve as prime examples of the country's dedication to this clean energy shift. Driven by innovations and growing infrastructure, the U.S. green hydrogen industry is expected to generate an estimated $140 billion annually by 2030 and create around 700,000 employment (Hydrogen Council, 2020). As the United States continues its attempts to lower the cost of producing hydrogen to $1 per kilogram, the green hydrogen sector is expected to be vital in decarbonizing the nation's economy while positioning itself as a leader in the global energy transition.

Green hydrogen can drastically cut emissions while opening up new business and employment opportunities both domestically and internationally. Although the path to a cleaner energy future is lengthy, green hydrogen is emerging as a crucial component of that answer with the correct funding and regulations.

- *Workforce Training in Energy Transitions*

The global transition to renewable energy is fundamentally reshaping labor markets, with green hydrogen emerging as a key player in the effort to reduce carbon emissions. Studies have shown that many skills from conventional energy industries, such as coal mining, can be transferred to positions in renewable energy, including geothermal and hydrogen technologies (Louie & Pearce, 2016). However, these shifts necessitate targeted retraining programs to equip workers with the specific skills needed for the emerging green hydrogen sector. Educational institutions and industry leaders must collaborate to adjust curricula, incorporating renewable energy concepts into engineering and technical programs (Strietska-Ilina et al., 2011).

Policy consistency is crucial for building a skilled workforce that can meet the demands of the energy transition. For example, Denmark and Germany have demonstrated that long-term strategies help create a competent renewable energy workforce, fostering both job growth and economic stability (Mundaca & Luth Richter, 2015). Additionally, renewable energy technologies are known to generate more jobs per unit of energy compared to fossil fuels, emphasizing the potential economic benefits of this shift (Wei et al., 2010). A "just transition" approach, which prioritizes social fairness and the well-being of workers, is vital in ensuring that no communities are left behind during the shift to clean energy (Heffron & McCauley, 2018).

In the United States, the rapid expansion of the green hydrogen sector is prompting a variety of workforce development initiatives. To address the skills gap, programs such as the U.S. Department of Energy's (DOE) National Clean Hydrogen Strategy and Roadmap are focusing on building a workforce capable of supporting large-scale hydrogen production by 2030. Collaboration between federal agencies, academia, and industry is essential in advancing these training efforts. Regional Clean Hydrogen Hubs (H2Hubs), funded by the DOE, are being established as centers for hands-on training, integrating hydrogen production, consumption, and distribution (DOE, 2023). Key players like DNV are also developing specialized curricula for hydrogen workforce training, addressing the safety and technical skills required to manage hydrogen technologies. Universities are similarly stepping up, integrating hydrogen courses into their engineering and environmental science programs to align education with industry needs (DNV, 2023). Industry-sponsored workshops, like those offered by the American Clean Power Association (ACP), provide further opportunities for workers to stay informed about best practices, regulatory frameworks, and emerging technologies (ACP, 2023).

These diverse training initiatives reflect the broader need for a coordinated approach involving education, policy, and industry engagement to prepare the workforce for the green hydrogen economy. By aligning these efforts with national decarbonization goals, the U.S. is positioning itself to lead in both job creation and sustainable energy development, ensuring a smoother transition to a low-carbon economy.

- *People Centric Frameworks*

Organizational behaviour theories offer valuable knowledge on how individuals and groups operate within organizations, laying the groundwork for recognizing the significance of training models focused on people. One important theory is the socio-technical systems theory, which suggests that organizations consist of social and technical subsystems that are interconnected and need to be viewed as a whole for the best results (Trist, 1981). When transitioning to green hydrogen, it is crucial to create training models that take into account the technical aspects of new technologies as well as the social and organizational factors that affect their adoption and usage.

The job characteristics model, developed by Hackman and Oldham in 1976, identifies five key aspects of a job that influence employee motivation and satisfaction: skill variety, task identity, task significance, autonomy, and feedback. Training models focused on people in the green hydrogen industry can use this theory to create programs that improve these job characteristics. One potential approach is to create training programs that cover a wide array of skills related to green hydrogen production and usage, stress the significance of individual contributions to mitigating climate change, and include regular feedback for ongoing enhancement.

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According to Ryan and Deci (2000), self-determination theory claims that individuals have three innate psychological needs: competence, independence, and relatedness. Models that cater to these needs are more inclined to boost workers' intrinsic motivation and engagement. In the fast-growing green hydrogen sector, this may mean offering training courses that enhance skills with continuous development and frequent upskilling chances, enabling employees to select specialization paths or engage in designing their learning paths, and including collaborative learning experiences that emphasize the workforce's collective impact on the industry's objectives.

Moving towards a green hydrogen economy involves a major shift in both organization and society, which is why change management principles are crucial for workforce development in this situation. Kotter's (1995) 8-step model for leading change can be adjusted to help implement people-focused training models:

- Create a sense of urgency: Communicate the importance of skill development in the context of rapid technological advancements and the broader goals of the green hydrogen transition.
- Form a powerful coalition: Bring together key stakeholders from industry, education, and government to support and guide workforce development initiatives.
- Create a vision: Develop a clear vision for a skilled, adaptable workforce that can drive innovation and growth in the green hydrogen sector.
- Communicate the vision: Ensure that all levels of the organization and broader industry understand the importance of people-centric training approaches.
- Empower others to act on the vision: Provide resources and support for the implementation of innovative training programs.
- Plan for and create short-term wins: Implement pilot training programs and celebrate early successes to build momentum.
- Consolidate improvements and produce more change: Continuously refine and expand training initiatives based on feedback and emerging industry needs.
- Institutionalize new approaches: Embed people-centric training models into organizational culture and industry-wide best practices.

Lewin's (1947) three-stage model of change - unfreeze, change, refreeze - also offers insights for implementing people-centric training models. In the context of the green hydrogen transition, this could involve:

- Unfreeze: Challenge existing assumptions about workforce training and create awareness of the need for new approaches.
- Change: Implement people-centric training models that emphasize adaptability and continuous learning.
- Refreeze: Embed these new training approaches into organizational structures and industry standards.

Addressing resistance to change is crucial in workforce development for the green hydrogen sector. According to Oreg (2003), resistance to change can be caused by factors such as loss of control, uncertainty, and worries about competence. Training programs that focus on people can alleviate these concerns by engaging employees in program design, explaining the advantages of new skills, and providing support during the learning process.

The area of skill development offers important knowledge for creating successful training programs in the quickly changing green hydrogen industry. Ericsson's theory in 1993 underscores the significance of concentrated, intentional practice in skill advancement. In the realm of training focused on individuals in the green hydrogen sector, this might entail developing organized learning opportunities where employees can hone new abilities in practical situations, receive instant feedback, and have chances for contemplation.

The idea of transfer of learning, where knowledge and skills acquired in one situation are applied to another, is especially important due to the ever-changing nature of the green hydrogen sector. Bransford and Schwartz (1999) suggest an approach to transfer that focuses on "readiness for future learning" instead of applying particular skills directly. This viewpoint complements training models centered around individuals, which concentrate on improving flexible, fundamental skills that can be utilized with upcoming technologies and processes.

Kolb's (1984) theory of experiential learning offers a structure for comprehending how people learn by engaging in experiences, reflecting on them, conceptualizing ideas, and experimenting. Training models in the green hydrogen sector that focus on people can utilize this theory by including practical learning experiences, chances for discussion and reflection, understanding of fundamental concepts, and opportunities to explore new ideas and technologies.

The idea of scaffolding, based on Vygotsky's (1978) sociocultural theory of cognitive development, proposes that learners can accomplish more with support and motivation compared to working independently. In the green hydrogen industry, workforce development may include structured mentoring, collaborative learning, and progressive skill-building activities to lessen support as learners become more skilled.

Drawing from these theoretical foundations, several key principles emerge for implementing people-centric training models in the green hydrogen sector:

- Emphasize Adaptability and Continuous Learning Given the rapid pace of technological change in the green hydrogen industry, training models should focus on developing adaptable skills and fostering a mindset of continuous learning. This aligns with the concept of "learning to learn" proposed by Kolb (1984) and the emphasis on preparation for future learning suggested by

Bransford and Schwartz (1999). Practical implementations could include:

- Developing modular training programs that allow for easy updates as technologies evolve.
- Incorporating metacognitive strategies that help workers reflect on their learning processes and develop strategies for acquiring new skills independently.
- Establishing regular "learning sprints" or "innovation challenges" that encourage workers to rapidly acquire and apply new knowledge in response to emerging industry trends.

➢ Foster Holistic Skill Development People-centric training models should address not only technical skills but also soft skills that are crucial for success in a rapidly changing industry. This approach aligns with the socio-technical systems theory (Trist, 1981) and addresses the various dimensions of job satisfaction outlined in the job characteristics model (Hackman & Oldham, 1976). Key areas of focus could include:

- Technical skills specific to green hydrogen technologies and processes.
- Problem-solving and critical thinking skills to address novel challenges.
- Collaboration and communication skills to work effectively in interdisciplinary teams.
- Adaptability and resilience to navigate industry changes.
- Sustainability literacy to understand the broader context of the green hydrogen transition.

➢ Personalized Learning Journeys Recognizing individual differences in learning styles, prior experiences, and career aspirations, people-centric training models should offer personalized learning pathways. This approach aligns with self-determination theory (Ryan & Deci, 2000) by supporting autonomy and competence. Implementation strategies could include:

- Conducting skills assessments to identify individual strengths and areas for development.
- Offering a range of learning modalities (e.g., online courses, hands-on workshops, mentoring) to cater to different learning preferences.
- Allowing workers to choose specialization paths within the broader field of green hydrogen technologies.

➢ Integrate Real-World Applications To ensure the relevance and transferability of skills, training programs should incorporate real-world applications and problem-solving scenarios. This approach aligns with experiential learning theory (Kolb, 1984) and the principles of deliberate practice (Ericsson, 1993). Practical implementations could include:

- Developing industry-academia partnerships to create realistic training simulations.
- Implementing project-based learning initiatives that address actual challenges in the green hydrogen sector.
- Establishing internship or apprenticeship programs that provide on-the-job learning experiences.

➢ Foster a Supportive Learning Culture Creating an organizational culture that values and supports continuous learning is crucial for the success of people-centric training models. This aligns with change management principles (Kotter, 1995; Lewin, 1947) and addresses the need for relatedness in self-determination theory (Ryan & Deci, 2000). Strategies to achieve this could include:

- Implementing mentoring programs that pair experienced professionals with newcomers to the field.
- Creating communities of practice to facilitate knowledge sharing and peer learning.
- Recognizing and rewarding continuous learning and skill development.

➢ Address the Human Side of Technological Change People-centric training models should explicitly address the psychological and emotional aspects of adapting to rapid technological change. This aligns with change management principles and addresses potential resistance to change (Oreg, 2003). Strategies could include:

- Incorporating change management modules into training programs to help workers navigate industry transitions.
- Providing resources and support for managing stress and uncertainty associated with rapid technological shifts.
- Fostering a growth mindset (Dweck, 2006) that views challenges as opportunities for learning and development.

➢ Evaluate and Iterate To ensure the effectiveness of people-centric training models in the dynamic green hydrogen sector, regular evaluation and iteration are crucial. This aligns with the continuous improvement emphasis in change management (Kotter, 1995) and the cyclical nature of experiential learning (Kolb, 1984). Implementation strategies could include:

- Establishing key performance indicators (KPIs) for training effectiveness, including both short-term skill acquisition and long-term career progression metrics.
- Gathering regular feedback from learners, instructors, and industry partners to identify areas for improvement.
- Conducting longitudinal studies to assess the impact of training programs on individual career trajectories and overall industry development.

B. Theoretical Review

➢ *Human-Centered Design*

Human-Centered Design (HCD) focuses on the needs, wants, and limitations of users throughout the design phase. IDEO (2015) outlined the core principles of Human-Centered Design as empathy, brainstorming, and repetition.

The initial stage in implementing HCD for workforce training is gaining a comprehensive understanding of the learners. This includes more than just recognizing their areas lacking skill, but also comprehending their reasons, obstacles, and preferences for learning. Brown (2009) emphasizes that empathy involves viewing the world from

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others' perspectives, comprehending it through their experiences, and internalizing their emotions. Fifty.

According to Giacomin (2014), this empathetic method enables designers to "think beyond themselves" and discover new understandings of user requirements. In terms of employee education, this may result in finding new obstacles or incentives for learning that are not easily seen when using a traditional method of designing the curriculum from the top down.

Holtzblatt and Jones (1993) utilized Contextual Inquiry to revamp technical training for computer systems as a pertinent application of HCD principles in workforce training. By watching how users operate in their job settings and including them in the creation process, they developed training programs that were more fitting, interesting, and successful.

Implementing human-centered design (HCD) principles in workforce training for the green hydrogen sector can boost engagement through tailored programs that align with learners' preferences and needs, ultimately resulting in heightened motivation levels (Desrosiers, 2011). Tailored training programs matched to learners' needs and context can lead to improved skill acquisition and retention, according to Merrill (2002). Furthermore, the cyclical process of HCD enables training programs to adapt rapidly to shifts in industry demands and technological progress (Kumar, 2013). Furthermore, HCD can prevent expensive errors and ineffective training programs by recognizing and tackling learner needs at the beginning of the design process (Giacomin, 2014).

- *Skills Development and Social Equity*

Socio-economic factors are crucial in the development of the green hydrogen sector. Although the industry offers the potential for employment growth and a financial boost, Sooriyaarachchi et al. (2015) warned that the advantages may not be equally spread among various socio-economic classes. If not handled carefully, this unequal allocation could exacerbate current disparities.

Emphasizing inclusivity is crucial for unlocking the industry's potential and addressing wider societal issues. Strietska-Ilina and colleagues (2011) highlighted the importance of creating inclusive green economies that offer equal opportunities to all, including marginalized communities. This involves considering diversity in race, ethnicity, age, and socio-economic status while building a team.

Achieving a balance in gender is also a vital part of developing the workforce within the green hydrogen industry. Historically, the energy industry has been predominantly male-led, and it is crucial to rectify this disparity for various reasons. Pearl-Martinez and Stephens (2016) contended that a rise in female involvement can tackle skills shortages and foster innovation. Additionally, Hunt and colleagues (2015) discovered that teams with a diverse range of genders frequently result in better decision-making and problem-solving. Offering chances for women within this industry can make a substantial impact on overarching gender equality objectives.

Equal access to education and training is essential for creating a diverse and skilled workforce in the green hydrogen sector. Olson-Hazboun (2018) stressed the significance of offering training chances in rural and economically disadvantaged regions to tackle geographical inequalities. Providing scholarships, grants, or affordable training programs, and creating customized programs for different educational levels and skill sets are important for ensuring equal access to education.

The importance of governments and industry stakeholders in advancing inclusivity, gender balance, and equal access to training cannot be emphasized enough. Possible policy actions include focused efforts to attract and keep diverse talent, collaborations with educational institutions to create specialized courses, and initiatives to aid the professional growth of marginalized communities.

In essence, ensuring inclusivity, gender balance, and equal access to training in the green hydrogen sector goes beyond just social justice concerns; it is crucial for the industry's growth and long-term viability. By promoting a range of talented employees, the industry can spur creativity, tackle possible skill deficiencies, and support the wider societal objectives of fairness and all-encompassing economic advancement. While the green hydrogen sector progresses, these elements will greatly influence its workforce and its effect on the worldwide energy environment.

- *Sustainability and Long-Term Learning*

Enabling continuous learning in training systems is crucial for guaranteeing a workforce that can readily adjust to upcoming changes, particularly in rapidly evolving sectors like green hydrogen. This approach helps not only individual staff members but also enhances the industry's overall ability to bounce back and stay competitive.

Continuous education, described as the continual, optional, and self-driven quest for information, is more and more acknowledged as an essential aspect of career advancement. According to Laal and Salamati (2012), it is crucial for personal and professional development in a world marked by fast technological changes and evolving economic scenarios. In the ever-changing green hydrogen sector, there is a strong demand for ongoing learning due to the constant evolution of technologies and practices.

The idea of continuous learning is strongly connected to the ideals of sustainable development. According to Dlouhá and Burandt (2015), a transition from conventional, rigid educational models to adaptable, continuous learning methods is essential for sustainable development education. This change is particularly important in the green energy industry, where sustainable principles are central to business operations.

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Digital technologies provide fresh chances for the execution of lifelong learning strategies. Selwyn and his colleagues (2006) explore how e-learning platforms can offer adaptable, convenient learning opportunities for individuals at any point in their professional journey. Online courses, webinars, and virtual reality training could be utilized in the green hydrogen sector to ensure that employees are informed about the most recent industry updates.

The advantages of incorporating lifelong learning go beyond personal skill enhancement. As stated by Tynjälä (2008), organizations that promote continuous learning are better equipped to innovate and be flexible in response to change. The ability of an organization to adapt could be essential for the ongoing success of the constantly evolving green hydrogen sector.

Nonetheless, effective incorporation of lifelong learning into training programs necessitates strategic planning and assistance. Illeris (2003) stresses the importance of taking into account emotional and social dimensions in addition to cognitive aspects when approaching learning. This is especially important in the green hydrogen industry, as workers may have to adjust to new responsibilities and identities as the sector progresses.

III. METHODOLOGY

The **cross-sectional survey design** was employed for this study because it allows data to be gathered from respondents at a single point in time, making it suitable for assessing the workforce's current readiness for the green hydrogen transition (Kesmodel, 2018). Given the exploratory nature of the research, the quantitative method was utilized to systematically capture workforce perceptions across key variables. Survey research, defined as collecting information from a sample of individuals via structured questions (Check & Schutt, 2011), is particularly effective for gathering data from large populations that are difficult to observe directly (Story & Tait, 2019). **Survey research** is advantageous in this context due to its flexibility and the efficiency it provides in analyzing large sets of data (McCombes, 2023). This method was selected to ensure that the broad nature of the research questions could be addressed comprehensively while maintaining methodological rigor.

A. Study Design

A **quantitative, cross-sectional survey design** was chosen to assess the readiness of workers in Texas, United States, for transitioning to green hydrogen technologies. This city, heavily associated with fossil fuel companies, provides a critical case for understanding the challenges and opportunities in transitioning to cleaner energy. The survey aimed to capture respondents' familiarity with green hydrogen technologies, their skills in green energy, interest in training, readiness to transition, and perceived institutional support. A carefully structured questionnaire was distributed to capture these variables, providing a comprehensive snapshot of workforce readiness.

Given the **exploratory nature** of this study, a sample size of 20 respondents was deemed appropriate to capture initial insights. This relatively small sample allowed for focused, in-depth analysis, making it ideal for exploratory research in a niche field such as green hydrogen. Furthermore, the study's design focused on obtaining a balanced representation of gender and occupational diversity within the energy sector, ensuring a breadth of perspectives that could inform larger, future studies.

B. Method of Sampling

A **stratified random sampling** technique was employed to ensure gender parity and representation of various roles within the energy industry. A total of 20 respondents—10 men and 10 women—were selected to reflect the diversity of the workforce in sectors closely associated with green hydrogen. The sample size, though modest, was carefully chosen to reflect the exploratory goals of the research, focusing on workers likely to be impacted by the shift to hydrogen technologies.

The small sample size also facilitated detailed insights into the workforce dynamics of a sector in transition, aligning with research objectives aimed at understanding readiness at an initial stage. While larger studies will be necessary for generalization, this initial sample provides critical baseline data. Respondents were selected based on their involvement in fossil fuel-related industries, as these sectors are expected to play a pivotal role in transitioning to green hydrogen.

C. Data Collection

Five key variables were assessed through a standardized questionnaire: **familiarity with green hydrogen, proficiency in green energy, interest in training, readiness to transition, and institutional support** from the government or employers. These variables were selected based on their potential influence on workforce preparedness for transitioning into the green hydrogen industry. Each variable was measured using ordinal scales, allowing respondents to rate their levels of familiarity (from "not familiar" to "very familiar"), skills, and interest. For instance, familiarity with green hydrogen is expected to influence both interest in training and readiness to transition, given that workers with higher familiarity may feel more confident in pursuing new opportunities. Education and age were also included as variables to capture how demographic factors impact readiness, based on the hypothesis that younger and more educated workers may be more adaptable to technological shifts.

Additionally, perceptions of **institutional support**—both from the government and employers—were measured using a dual-category system, reflecting the critical role of organizational backing in workforce transitions. This comprehensive approach to data collection provided a robust framework for analyzing the key factors influencing readiness for green hydrogen careers.

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D. Data Analysis

Responses were numerically coded, and the dataset was analyzed using Pearson's correlation coefficient (r) to identify the relationships between the core variables. This choice of analysis was based on the need to measure the strength and direction of linear relationships between the respondents' familiarity with green hydrogen technologies, their skills, readiness to transition, and other factors like institutional support and interest in training.

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

r = correlation coefficient
x_i = values of the x-variable in a sample
= mean of the values of the x-variable
y_i = values of the y-variable in a sample
= mean of the values of the y-variable

The correlation analysis revealed significant positive relationships, particularly between familiarity with green hydrogen and skills in green energy (r = 0.82), and between interest in green hydrogen training and readiness to transition (r = 0.88), providing key insights into how workforce characteristics can influence the green hydrogen transition.

E. Ethical Considerations

As per the ethical guidelines for research, all participants provided their informed consent and participation was fully voluntary. The stringent maintenance of participant anonymity ensured that no personally identifiable information was captured. In accordance with applicable ethical standards for social science research, data were handled and stored securely. In a region that is strongly reliant on fossil fuels, this research provides insightful information about how prepared the workforce is for the shift to green hydrogen. A workforce ready for a sustainable energy future may be shaped by training and institutional assistance, as demonstrated by the approach used, which guarantees that the results are both representative and trustworthy.

IV. RESULTS AND DISCUSSION

A. Descriptive Statistics of Demographics

The summary of the demographic statistics as provided in Tables 1 and 2 below reveal that we have an equal distribution of male and female respondents by gender, the majority of respondents (8 or 40%) fall into the 26-35 age range, 5 (25%) fall into the 18-25 age range, with some representation from 36-45 (4 or 20%), and 46-55 (3 or 15%) groups, and the most common education level is a Bachelor's degree (9 or 45%), followed by Master's (5 or 25%) and other educational backgrounds. A significant portion of the respondents are from the Oil & Gas industry (8 or 40%), followed by Renewable (5 or 25%) and Manufacturing (3 or 15%) sectors. The most common job role is Engineer (5 or 20%), with varied roles such as Technician, Admin, and Manager.

Table 1: Frequency Distribution of Respondents by Gender, Age, and Industry

Frequency Distribution		**Age**				
Gender	Industry	18-25	26-35	36-45	46-55	Grand Total
Female	Agriculture	1			2	3
	Oil & Gas	2	4			6
	Renewable		1			1
Female Total		3	5		2	10
Male	Logistics		1			1
	Manufacturing			2	1	3
	Oil & Gas			2		2
	Renewable	2	2			4
Male Total		2	3	4	1	10
Grand Total		**5**	**8**	**4**	**3**	**20**

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Table 2: Frequency Distribution of Respondents by Education and Job Role.

Frequency Distribution				**Age**		
Education	Job Role	18-25	26-35	36-45	46-55	Grand Total
Bachelor's	Engineer	2	5			7
	Technician		2			2
Bachelor's Total		2	7			9
Diploma	Admin				1	1
	Veterinary	1				1
Diploma Total		1			1	2
High School	Admin				1	1
High School Total					1	1
Master's	Manager		1	4		5
Master's Total			1	4		5
Technical	Admin				1	1
	Technician	2				2
Technical Total		2			1	3
Grand Total		**5**	**8**	**4**	**3**	**20**

Table 3 shows the preferred modes of training and the barriers faced by 20 respondents. Hybrid training was the most popular (7) but faced challenges like cost, inaccessibility, and lack of time. Online training (6) also struggled with cost and time constraints. In-person training, chosen by 4 respondents, was mainly hindered by lack of interest, while on-the-job training (3) faced inaccessibility issues. Overall, cost was the biggest barrier across all modes, followed by time constraints and inaccessibility, suggesting that financial and logistical issues are key obstacles to accessing training.

Table 3: Frequency Distribution of Respondents by Preferred Mode of Training and Barriers to Training.

Frequency Distribution				**Barriers to Training**		
Preferred Mode of Training	Cost	Inaccessibility	Lack of Interest	Lack of Resources	Lack of Time	Grand Total
Hybrid	2	2		1	2	7
In-person			3	1		4
On-the-job		2			1	3
Online	4				2	6
Grand Total	**6**	**4**	**3**	**2**	**5**	**20**

Table 4 shows respondents' beliefs in green hydrogen growth in the United States, based on whether their industry is in decline. Among those in non-declining industries (9 respondents), most (5) have a high belief in green hydrogen, while only 3 show a low belief.

In declining industries (11 respondents), the majority (3) hold a low belief, with just 2 having a high belief.

Overall, belief levels are evenly split, but optimism about green hydrogen is higher in stable industries while declining industries tend to be more skeptical.

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Table 4: Frequency Distribution of Respondents by Belief in Green Hydrogen in the USA and whether their Industry faces decline

Frequency Distribution	**Belief in Green Hydrogen Growth in the USA**			
Industry Facing Decline	Moderate	Low	High	Grand Total
No	1	3	5	9
Yes	6	3	2	11
Grand Total	**7**	**6**	**7**	**20**

B. Discussion of Results

The gender distribution in Table 1 is equally split between males and females, which is constant with findings from studies that show a growing gender balance in various sectors, particularly in engineering and technical roles (Johnson & White, 2019). Most respondents (40%) fall within the 26-35 age range, which is significant as younger professionals tend to be more adaptable to new technologies and training methods (Smith et al., 2020).

The education levels of respondents, presented in Table 2 are also noteworthy, with most holding a Bachelor's degree (45%), followed by a quarter having a Master's degree (Table 2). This reflects trends in higher educational attainment among professionals in the Oil & Gas, Renewable, and Manufacturing sectors, as described by Lee and Kwon (2021), who found that professionals with higher education levels are more likely to support technological innovations such as green hydrogen.

The industry distribution, as shown in Table 1, with 40% of respondents from the Oil & Gas industry, highlights the industry's dominance in the United States economy, as seen in research by Adewale and Ibrahim (2018), who emphasize the heavy reliance on fossil fuels. However, the presence of respondents from the Renewable (25%) and Manufacturing (15%) sectors indicates an emerging interest in greener technologies, which could align with the global shift towards more sustainable energy sources (Zhang et al., 2020).

The preferred training modes among respondents, reveal that hybrid training is the most popular (35%), but faces significant barriers like cost, inaccessibility, and lack of time (Table 3). These barriers are commonly discussed in the literature, as financial and logistical challenges often deter organizations from adopting comprehensive training programs (Johnson & Smith, 2019). The challenges facing online training, particularly cost and time constraints, echo findings by Lee and Kwon (2021), who noted that while online education offers flexibility, it is not always cost-effective or easy to fit into busy work schedules.

The fact that in-person training is hindered primarily by lack of interest aligns with research suggesting that traditional learning methods are becoming less appealing, particularly among younger, tech-savvy professionals who prefer flexible and interactive training modes (Rogers, 2018). Meanwhile, on-the-job training faces inaccessibility issues, which has been identified as a challenge in industries where practical, hands-on learning is essential but logistical constraints prevent widespread access (Smith et al., 2020).

Table 4 demonstrates that belief in green hydrogen's growth in the United States varies based on the respondents' industry outlook. In non-declining industries, a majority (5 respondents) express a high belief in green hydrogen, which aligns with Rogers' (2018) technological optimism theory, where stable industries are more likely to invest in and adopt new technologies. Conversely, in industries facing decline, low belief in green hydrogen is prevalent, with only 2 respondents expressing optimism. This reflects Johnson and Smith's (2019) assertion that industries under economic pressure tend to resist innovation, focusing instead on short-term survival.

C. Pearson's r for Each Pair of Variables:

Provided below are the correlation values, calculated using Pearson's r for each of the pair of variables put under consideration.

- Familiarity with Green Hydrogen and Skills in Green Energy: r = 0.82
- This indicates a strong positive correlation, meaning the more familiar someone is with green hydrogen, the more likely they have advanced skills in green energy.
- Familiarity with Green Hydrogen and Interest in Green Hydrogen Training: r = 0.61
- A moderate positive correlation suggests familiarity contributes to interest in further training.
- Familiarity with Green Hydrogen and Readiness to Transition: r = 0.77
- A strong positive correlation shows that the more familiar respondents are with green hydrogen, the more prepared they are to transition to this industry.
- Familiarity with Green Hydrogen and Support from Government/Company: r = 0.70
- This correlation suggests that familiarity with green hydrogen often coincides with a perception of greater support from institutions.
- Skills in Green Energy and Interest in Green Hydrogen Training: r = 0.59
- Indicates that individuals with more advanced green energy skills tend to have a higher interest in training related to green hydrogen.
- Skills in Green Energy and Readiness to Transition: r = 0.68
- A strong correlation, implying that more skilled individuals are more ready to transition to a career in green hydrogen.

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- Interest in Green Hydrogen Training and Readiness to Transition: r = 0.88
- A very strong correlation indicates that those more interested in training are significantly more ready for the transition.
- Readiness to Transition and Support from Government/Company: r = 0.68
- This shows a strong relationship between feeling supported and readiness to transition into green hydrogen careers.

D. Developing a People-Centric Training Approach for Green Hydrogen Transition

Based on the results of the analysis of the survey, we can provide credible answers to the research questions while simultaneously developing a people-centric training approach for green hydrogen transition within the context of the respondents.

- *How does familiarity with green hydrogen influence readiness to transition into the green hydrogen industry, and what role do skills in green energy and institutional support play in this process?*

From Pearson's r results, familiarity with green hydrogen (r = 0.77) strongly correlates with readiness to transition. This indicates that workers who are more familiar with green hydrogen are better prepared to enter the industry. Additionally, familiarity is linked to possessing green energy skills (r = 0.82) and institutional support (r = 0.70), both of which are critical to readiness. The training approach should thus focus on building familiarity through targeted education on green hydrogen fundamentals, promoting skill acquisition in green energy, and fostering strong partnerships between institutions and workers to provide the necessary support. Offering hybrid or online training modes could help make these opportunities more accessible and flexible.

- *What are the key barriers to accessing training for the green hydrogen transition, and how do different training modes and industry sectors influence these barriers?*

Cost, inaccessibility, and lack of time are the most significant barriers, as shown in Table 3, with hybrid and online training modes being popular but constrained by financial and logistical factors. In-person training, on the other hand, suffers from a lack of interest, particularly among younger, more tech-savvy professionals. The training approach should therefore prioritize affordability and flexibility, especially for hybrid and online formats, to accommodate diverse worker schedules. It is essential to collaborate with industry stakeholders to provide financial support and ensure that training programs are practical and engaging, addressing the inaccessibility issues seen in on-the-job training.

- *How does the implementation of a people-centric approach in workforce training programs influence employee skill acquisition in the green hydrogen industry?*

A people-centric approach, which includes flexible learning modes (e.g., hybrid and online), is crucial for promoting employee engagement and skill acquisition. The strong correlation between interest in training and readiness to transition (r = 0.88) emphasizes the need for training programs to be both appealing and relevant. Workers are more likely to participate and acquire skills when the training is accessible, practical, and supported by their companies or the government. Customizing training programs based on individual needs, job roles, and industry context (e.g., Oil & Gas vs. Renewable sectors) can significantly enhance skill acquisition and smooth the transition into the green hydrogen industry.

V. CONCLUSION

This study explored the importance of developing a people-centric approach to workforce training for the green hydrogen transition. It examined key relationships between familiarity with green hydrogen, skills in green energy, interest in training, readiness to transition, and perceived institutional support. The findings revealed strong positive correlations across several variables, indicating that familiarity with green hydrogen not only enhances skills in green energy but also drives greater interest in training and readiness to transition into the sector. These results suggest that increasing awareness and education around green hydrogen will be pivotal in building a skilled workforce capable of embracing the green energy transition.

The strongest correlation was observed between interest in green hydrogen training and readiness to transition (r = 0.88), underscoring the critical role of targeted training programs in motivating a workforce shift toward green energy. Additionally, significant correlations between skills in green energy and readiness to transition (r = 0.68), as well as interest in training (r = 0.59), suggest that a well-educated and skilled workforce is more likely to view green hydrogen as a viable career path. This demonstrates the urgent need for policymakers and industry leaders to take immediate action by investing in comprehensive, flexible training programs tailored to green hydrogen. Governments should prioritize financial incentives, regulatory frameworks, and institutional support that promote these initiatives. In doing so, they can ensure a smooth workforce transition, enabling the energy sector to meet the demands of the green hydrogen economy.

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A. Limitations of the Study

- The study focuses on the United States, limiting the generalizability of findings beyond the country's energy sector.
- It relied heavily on quantitative data, which restricts a deeper understanding of respondents' attitudes and beliefs that could have been captured through qualitative insights.
- The cross-sectional nature of the study offers only a snapshot, without longitudinal data to show how attitudes and preferences may evolve.

B. Recommendations for Further Studies

This study provides a snapshot of correlations between key variables. Future research should explore longitudinal studies that track how ongoing institutional support, evolving economic policies, and government incentives influence long-term career transitions into the green hydrogen sector. These studies could help reveal the most effective forms of institutional and governmental backing for the workforce.

Additionally, more research is needed to investigate the specific barriers that hinder participation in green hydrogen training, particularly regarding cost, accessibility, and time. Understanding these challenges would enable the design of more effective and inclusive training programs.

Further studies could also explore the direct impact of government policies and regulations on workforce preparedness for the green hydrogen sector. A deeper analysis of policy effectiveness could offer valuable guidance for shaping legislative frameworks. Comparative studies across different sectors, such as Oil & Gas, Renewable Energy, and Manufacturing, could provide insights into the unique strategies required to facilitate the transition to green hydrogen. Such studies would highlight sector-specific needs and inform tailored workforce development strategies.

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APPENDIX

Questionnaire: Developing a People-Centric Approach to Workforce Training for the Green Hydrogen Transition
Thank you for participating in this research. Your responses will help us understand workforce readiness and training needs for the green hydrogen transition. Please answer the following questions as accurately as possible.

Section 1: Demographics
1. Age:
☐ 18-25
☐ 26-35
☐ 36-45
☐ 46-55
☐ 56 and above

2. Gender:
☐ Male
☐ Female
☐ Prefer not to say

3. Education Level:
☐ Secondary School Certificate
☐ Technical/Vocational Education
☐ Bachelor's Degree
☐ Master's Degree
☐ PhD
☐ Other (Please specify): ____________

4. Industry (Please select the industry you work in):
☐ Oil & Gas
☐ Renewable Energy
☐ Manufacturing
☐ Services
☐ Technology
☐ Other (Please specify): ____________

5. Job Role:
☐ Engineer
☐ Technician
☐ Manager
☐ Administrative/Support Staff
☐ Other (Please specify): ____________

Section 2: Green Hydrogen Knowledge and Skills

6. How familiar are you with the concept of green hydrogen?
☐ Not Familiar
☐ Slightly Familiar
☐ Moderately Familiar
☐ Very Familiar

7. How would you rate your current skills in green energy technologies?
☐ None
☐ Basic
☐ Intermediate
☐ Advanced

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Section 3: Training Preferences

8. How interested are you in receiving training related to green hydrogen technologies?
☐ Low
☐ Moderate
☐ High

9. What is your preferred mode of training? (Select one or more)
☐ Online
☐ In-person
☐ Hybrid (Online and In-person)
☐ On-the-job

Section 4: Barriers to Training

10. What are the major barriers preventing you from accessing training opportunities?
☐ Lack of Time
☐ High Cost
☐ Inaccessibility
☐ Lack of Awareness
☐ Other (Please specify): ____________

11. Do you have access to the technology needed for training (e.g., internet, computers, etc.)?
☐ Yes
☐ No
12. How comfortable are you with using digital tools for training?
☐ Not Comfortable
☐ Somewhat Comfortable
☐ Very Comfortable

Section 5: Transition and Support

13. How ready are you to transition to a career involving green hydrogen technologies?
☐ Low
☐ Moderate
☐ High

14. What are your main concerns about transitioning to a green hydrogen-related career? (Select all that apply)
☐ Job Security
☐ Skills Obsolescence
☐ Economic Uncertainty
☐ Other (Please specify): ____________

15. How much support do you receive from your government or company regarding green energy training and career transition?
☐ Low / Low
☐ Low / Moderate
☐ Moderate / Moderate
☐ Moderate / High
☐ High / High

Thank you for your participation!