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HumanEnerg Hotspot: Conceptual Design of an Agile Toolkit for Human Energy Reinforcement in Industry 5.0

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Abstract: This paper presents the conceptual design of the HumanEnerg Hotspot, an agile toolkit aimed at addressing the human energy crisis in the context of Industry 5.0. The toolkit has been developed using a blend of Design Science Research (DSR) and Human-Centered Design (HCD) methodologies, enabling a comprehensive human-centered problem identification and solution-seeking approach. The toolkit includes a variety of strategies, techniques, frameworks, and resource recommendations for industry use and has been designed to be easily adaptable for use in diverse industry settings. The toolkit is intended to support the European Union's goal for industry to influence society through a human-centric approach to Industry 5.0 by prioritizing human energy reinforcement and creating a more resilient and productive workforce. The toolkit provides a valuable resource for employees and managers alike and offers a promising solution for addressing the human energy crisis in the era of Industry 5.0.

Keywords: human energy; Industry 5.0; toolkit; human-centricity; human energy crisis; sustainability

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1. Introduction

Today's economy runs on human potential [1]. Significant dynamics in the progressive movement from Industry 4.0 to Industry 5.0 transcending efficiency and productivity are the emphasis on industry human-centricity and, also, the reinforcement of the role and contribution of industry to society [2,3]. The escalating global decline in human energy levels, encompassing mental fatigue, diminished surge capacity, emotional exhaustion, and anxiety, can be linked to the expansive social, technological, economic, and cultural evolutions that have transpired over the years [4]. This is especially the case with industry transformations occurring globally from an industry-based economy to a knowledge-driven one, and now to an economy that relies on the heart, mind, and inherent human qualities—essentially, our humanity [4]. For the past couple of years, escalating global challenges, such as the pandemic, social unrest, economic inflation, climate change, and rapid technological advancements, have converged with work-related stress to further erode the positive psychological states of individuals in society, contributing to a plethora of mental, cardiac, and other health issues [5,6]. While many of these stressors are beyond an employer's control and the future remains uncertain, leaders and managers can still make a meaningful impact on the employee experience and work-life journey, helping them thrive despite energy-depleting challenges [6,7]. Human energy reinforcement in Industry 5.0 is a human-centric initiative of Industry 5.0 aimed at mitigating the human energy crisis [6]. It contributes to addressing the research and innovation challenges faced by the European Union (EU) in sustaining the well-being and sustainability of human lives, particularly within the context of industry [3,6]. This concept of designing represents a

proactive strategy wherein industries contribute to societal well-being by systematically incorporating appropriate resources to support the employee experience, mitigating the human energy crisis, one industry at a time [5–7]. Given the novelty of this human-centric initiative, many organizations may struggle with adoption and implementation ideas. A human energy reinforcement toolkit can serve as a valuable resource hotspot for organizations of all sizes and industries.

Objectives

This paper presents the conceptual design of the HumanEnerg Hotspot, an agile toolkit aimed at addressing the human energy crisis in the context of human-centricity in Industry 5.0 under the theme of human energy reinforcement in Industry 5.0. Its purpose is to provide a structured and comprehensive approach to developing and deploying human energy reinforcement strategies, offering a variety of tools, methods, and frameworks to support and guide the process. Through pragmatic stressor identification and solution-seeking techniques, this paper researches and compiles human energy reinforcement strategies and ideas, designing frameworks that facilitate industry adoption and practical applications. This can serve as a valuable resource for Industrial Engineering and HR Management, particularly in Lean Management environments, advancing Industry 5.0's objectives in alignment with the European Union's vision for industry and its societal responsibilities. The HumanEnerg Hotspot aims to be a go-to resource of human energy reinforcement strategies, enabling seamless industry adoption and encouraging proactive efforts to tackle the human energy crisis.

2. Background

The term "Industry 5.0", introduced by the European Commission [8], is a paradigm that complements the existing Industry 4.0 model through its emphasis on research and innovation as drivers for a sustainable, human-centric, and resilient European industry [3,9]. While the general concept of human-centricity in Industry 5.0 has been articulated, its implications for future operations remain underexplored [9]. In that context, [10] emphasizes the concept of human-centricity in Industry 5.0 as still being in its nascent stage, necessitating an urgent collaborative dialogue, requiring a new research effort. Recognizing prior works in areas such as ergonomics [11], human–robot collaboration [12], and Operator 4.0 as embedded within a system-centric automation context, [10] argues that human-centricity in industry should reflect a focus on human-centered research. Consequently, this paper's authors proposed the Industrial Human Needs Pyramid, encompassing basic needs, such as safety and health, up to the highest level of esteem and self-actualization [10]. Furthermore, [13] admits that the progression of manufacturing towards Industry 5.0 is generally steered by human-centricity as a core principle. One of the major challenges outlined by the European Union in Industry 5.0's transformative vision is a rapid transformation of human life to enable 8 billion people live sustainably and peacefully within planetary boundaries [3,6].

The European Union's human-centric vision for the fifth Industrial Revolution (Industry 5.0) serves as the driving force behind the research on human energy reinforcement in industry [6]. The 'human energy reinforcement' viewpoint places the well-being of workers at the core of the manufacturing process, surpassing the emphasis on efficiency and productivity and highlighting industry role and contribution to society [6,8,10]. Dyvik (2024)'s data reveal an employment-to-population ratio estimation to comprise around 58 percent of individuals aged 15 and above as part of the global workforce [14]. Given that most adults devote a significant portion of their waking hours at work, the industrial sector is uniquely positioned to have a considerable impact on influencing the employee experience to mitigate the human energy crisis.

2.1. The Human Energy Crisis

In an effort to define 'human energy', Quinn et al. (2012) conducted a review of interdisciplinary literature and identified two fundamental components: physical energy and energetic activation [15]. Physical energy, grounded in physiological elements such as blood glucose levels or Adenosine triphosphate (ATP) availability in cells, is defined as the capacity to perform work [6,15,16]. In contrast, energetic activation pertains to the subjective component of human energy, encompassing feelings of vitality, enthusiasm, and liveliness [15] (p. 341). Around 45% of individuals, according to Wells (2024), suffer from chronic fatigue, while seven out of ten people report that they are struggling or suffering [5,17]. The world is currently facing a human energy crisis, impacting individuals in both their personal and work environments. The papers [5,17–20] describe the human energy crisis as a multifaceted syndrome characterized by intense exhaustion, cynicism, and a reduced sense of effectiveness. Far beyond burnout, which the World Health Organization has identified as an occupational phenomenon [5,21], the human energy epidemic has worsened over the years due to ever-escalating events in the industry's external environment, such as the pandemic, social unrest, advancements in technology, and economic uncertainties [5–7]. One of the key aspects of chronic fatigue is its mental component, which is driven by heightened stress, anxiety, and a persistent feeling of being overwhelmed by life's demands [22]. Chronic stress can deplete our mental capacities, making it difficult to engage in daily activities such as exercise, maintain focus at work, and maintain healthy relationships with others [17,22]. This study tilts more towards mitigating the subjective component of human energy "energetic activation" as it pertains to mental fatigue, feelings of emotional exhaustion, stagnation, depersonalization, diminished surge capacity, lack of achievement, and anxiety, rather than to the role physical energy plays in human behavior with the manipulations of food intake or blood sugar levels [6,15].

2.2. Human Energy Reinforcement in Industry 5.0

As global conditions continue to deteriorate, more people become exhausted and burnt out, struggling to thrive [5,7]. The European Union's human-centric approach to Industry 5.0, coupled with the significance of the workforce population in society, presents an opportunity for the industrial sector to play a key role in addressing the human energy crisis [6]. Human energy reinforcement in industry entails the deliberate strategic management of employee energy levels by effectively harnessing, sustaining, and aligning them to achieve sustained high performance (SHP) within an organization while also indirectly responding to the increasing global concerns about human energy depletion [6]. By intentionally incorporating strategies to help employees overcome current and imminent stressors to improve their vitality, the industrial sector can leverage its influence to enhance well-being and energy among its workforce, thereby contributing to a healthier and more resilient society [5–7].

This thesis explores the potential of the industrial sector to address the human energy crisis through the implementation of employee-vitality-enhancing strategies within industry. The term "human energy reinforcement" in the context of the industry is a subset of "human sustainability". Deloitte's 2024 report describes human sustainability as the degree to which organizations generate value for individuals, leading to better health and well-being, upgraded skills and employability, quality employment opportunities, prospects for advancement, movement towards equity, enhanced feelings of belonging, and a stronger connection to purpose. This implies that 'human sustainability' is equivalent to 'human energy reinforcement in industry' and more [1]. Human energy reinforcement is a comprehensive approach that involves promoting practices, strategies, and initiatives to enhance the employee experience and improve resilience, well-being, and overall vitality in the workforce. Its purpose is to enable as many humans as possible to thrive amidst the growing stressor events emanating from within and outside the industry environment. According to Klinghoffer and McCune, "thriving" means being energized and empowered to engage in meaningful work in one's position [23]. Therefore, an employee with

high human energy is considered a thriving employee, and thriving people contribute to thriving businesses [1]. The primary objectives of the 'human energy reinforcement in industry' agenda are to build resilience and the ability to thrive despite current and impending stressors and to increase industry productivity. The concept of 'resilience' refers to the ability of individuals to adapt and thrive even when faced with adversity [24,25]. It is apparent that the way individuals cope with challenging or unfavorable situations is influenced by the protective and risk factors present in their work environments [25,26]. In this context, risk factors can refer to stress triggers that deplete human energy while protective factors represent strategies that industries can implement to reinforce human energy. It has been demonstrated that 'resilience' is not merely a personal trait but rather a multifaceted construct stemming from the dynamic interplay between risk factors and protective factors [24,27]. Ruggeri et al. assert that human energy and well-being are sustainable conditions that enable individuals or populations to develop and thrive [28].

In the context of 'Human energy reinforcement in Industry 5.0', the industry plays the important role of proactively incorporating protective factors into an employee's journey to help alleviate the risk factors that cause human energy depletion. In other words, by supporting their employees' energy, industries indirectly impact society by fostering individuals to feel good and function well [6]. This includes experiencing positive emotions such as happiness and contentment, developing one's potential, having some control over one's life, maintaining a sense of purpose, and experiencing positive relationships despite current and imminent stressors [29]. To achieve this, industries can take advantage of tool recommendations included in a human energy reinforcement toolkit, which offers the most effective solutions for managing stressor situations. This toolkit guides identifying the issue, strategizing solutions, executing plans, and evaluating results. A toolkit is a set of reliable and flexible resources designed for front-line staff, empowering them to understand an issue and determine strategies to tackle it.

2.3. Measurement of Human Energy

A major human energy reinforcement strategy in industry is a regular assessment of employee energy to identify emerging stress triggers. The 'HumanEnerg Hotspot' toolkit will incorporate various measures for assessing human energy levels, allowing for the refinement of already deployed strategies and the introduction of new ones to further enhance employee vitality.

Human energy can be assessed from different perspectives: physiological, psychological, or behavioral aspects. Some common methods for assessing human energy levels include the following:

- Self-report measures are surveys or questionnaires designed to assess individuals' subjective feelings of energy, vitality, or fatigue. Examples of such assessment tools include the Profile of Mood States (POMS) [30] and the Subjective Vitality Scale (SVS) [31,32]. As these are versatile and adaptable to diverse populations and settings, employers can understand the subjective states of individuals and tailor interventions or support accordingly.
- Physiological measures are methods used to assess an individual's energetic state by measuring various physiological markers. These markers can include heart rate variability, cortisol levels, and brain activity as measured through electroencephalography (EEG). Wearable technologies such as smart watches, fitness trackers, and sleep monitors can also be used to collect physiological data and provide insights into an individual's energy levels. These methods allow for objective and quantifiable measurements of energy and can be useful for tracking changes over time and evaluating the effectiveness of interventions.
- Behavioral measures involve evaluating and quantifying specific behaviors or performance outcomes that reflect an individual's capacity to thrive and perform optimally. Examples include engagement levels and motivation [33], cognitive functioning, creativity and innovation, resilience and adaptability [26], social and emotional intelli-

gence, proactive behavior, collaboration, and work–life balance. Also, one can likely pick up subtle and not-so-subtle cues of energy depletion when individuals admit to or show a decline in activity levels; physical symptoms; avoidance and withdrawal behaviors from situations, tasks, or responsibilities; procrastination; irritability; social withdrawal/reduced communication; support-seeking, etc. [34]. These measures can include both self-reported assessments of energy levels, productivity, and engagement as well as objective measures such as task completion rates and performance metrics.

However, well-being as a multidimensional construct, varies across studies, and cannot be effectively measured using only a single item about life satisfaction or happiness or a limited set of items regarding the quality of life. Ruggeri et al. believe that an informative measure of well-being should encompass all the major components of well-being [28].

Derived from the opposites of the major symptoms of anxiety and stress, Ruggeri et al., 2020 came up with ten features of psychological well-being: autonomy, emotional stability, engagement, meaning, environmental mastery, personal growth, positive relationships, resilience, self-esteem, and vitality [28,35]. Each of these dimensions are typically measured, and then aggregated into an overall well-being index, to derive a single well-being score, summarizing an individual's overall level of well-being [28,35,36]. The 'HumanEnerg hotspot' will include guides for both single-item measurements of individual well-being components and a comprehensive single-score measurement that summarizes a person's well-being based on ten items.

In a comprehensive study on measuring human energy, Weigelt et al. tapped into recurring literature on occupational strain and recovery, which frequently employs the metaphor of individuals needing to "recharge their batteries" to sustain their energy levels [32]. The researchers utilized the battery metaphor as depicted in Figure 1 to capture the concept of energetic activation [32]. They developed a single-item pictorial scale to assess energetic activation to show one feeling at the moment; human energy levels ranged from 'depleted' to 'fully charged'.

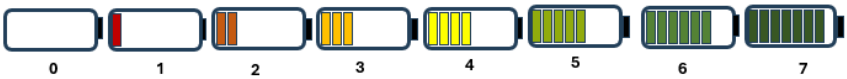

Figure 1. Battery scale response options ranging from a depleted to a fully charged battery [32].

Their research showed that the scale surpassed the purely verbal scale in terms of response latencies and the participant-rated user experience and was less challenging to respond to than abstract numerical percentage values. The pictorial scale minimizes the participants' burden during measurement, prevents survey fatigue, and ultimately reduces high dropout rates [32,37]. Due to their time efficiency and reduced cognitive load for respondents, Weigelt et al. consider pictorial scales to be a silver bullet in measuring energetic activation. The 'HumanEnerg Hotspot' toolkit will be populated with various energetic activation scales, encompassing various measures for vitality and fatigue with terms like "exhausted", "worn out", and "tired"; enthusiasm with terms like "elated", "enthusiastic", and "euphoric"; tension with terms like "tense", "on edge", and "nervous"; and serenity with terms like "relaxed", "serene", and "at rest".

2.4. Theoretical Framework

The design of the human energy reinforcement toolkit integrates principles from psychology, organizational behavior, and strategic management to provide a comprehensive and holistic approach for designing and implementing workable strategies that boost human energy. These theories offer a conceptual structure that enables a systematic and consistent approach to comprehending, analyzing, and interpreting the subject matter. The theoretical frameworks provide a well-founded rationale that underpins the design and application of the various tools in the toolkit. Good theoretical frameworks ensure that research decisions and findings are guided by established facts from credible studies rather than relying solely on personal instincts or conjectures.

The Cognitive–Transactional Model, developed by Richard Lazarus and Susan Folkman in the 1980s, is a prominent framework for understanding stress, coping, and adaptation. This model emphasizes the dynamic and reciprocal relationship between individuals and their environment, focusing on how people perceive and respond to stressors [38,39]. According to the model, a person first engages in primary appraisal, where they check to see whether the event or situation is stressful, benign, or irrelevant. After identifying a stressor, individuals evaluate their coping resources and options (secondary appraisal) [40]. This involves assessing internal (e.g., resilience, skills) and external (e.g., social support, financial resources) factors to determine how to manage the stressor effectively (cognitive appraisal process), as well as the assessment of their ability to cope with it. The model highlights the dynamic and transactional nature of stress and coping processes, where stress is viewed as an ongoing interaction between individuals and their environments rather than a static event [41,42]. It points out two types of coping strategies: problem-focused and emotion-focused coping strategies. Problem-focused coping involves efforts to change or manage the stressful situation itself while emotion-focused coping involves regulating one's emotional response to the stressor. The effectiveness of coping strategies depends on factors such as the nature of the stressor and the individual's appraisal of the situation. Coping strategies are continually reassessed and adjusted based on feedback from the environment and the outcomes of previous coping efforts [22]. The Cognitive–Transactional Model could be incorporated into the "HumanEnerg Hotspot" toolkit in several ways. For example, the toolkit could include resources and strategies for helping individuals to engage in problem-focused coping and emotion-focused coping in response to stressors related to energy depletion. This could include both techniques for identifying and addressing the sources of stress as well as strategies for managing emotions and reducing distress. Overall, incorporating the Cognitive–Transactional Model into the "HumanEnerg Hotspot" toolkit could help individuals better manage stress and energy depletion and develop more effective coping strategies for maintaining their well-being in the face of challenging situations.

Self-Determination Theory (SDT) is a well-established psychological framework for understanding human motivation, personal development, and overall well-being. Developed by Edward L. Deci and Richard M. Ryan, SDT posits that individuals have inherent growth tendencies and innate psychological needs for autonomy, competence, and relatedness [31,43]. It offers insights into how intrinsic and extrinsic factors shape motivation and how the interplay between internal desires and external influences determines the sustainability and quality of motivation [44]. These inherent growth tendencies are strengthened when individuals experience a sense of control over their actions (autonomy), feel capable of accomplishing tasks (competence), and maintain meaningful connections with others (relatedness) [31,45]. Meeting these needs is essential for fostering intrinsic motivation, enhancing well-being, and achieving optimal functioning [45,46], which are key objectives of human energy reinforcement in industry. Sustaining environments that promote autonomy, create opportunities to develop competence, and foster relatedness amplifies inherent growth tendencies [31,44–46] and can also provide a foundational reinforcement strategies for addressing most stress triggers. Self-Determination Theory (SDT) has been the basis for numerous toolkits, including one detailed by [44–46]. This toolkit employs SDT as a theoretical framework to guide technology designers in improving the psychological effects of their creations. It offers practical advice on integrating SDT principles into technology design, aiming to promote user autonomy, competence, and relatedness, thus enhancing overall well-being and motivation. Similarly, the "HumanEnerg Hotspot" toolkit draws on the principles of Self-Determination Theory (SDT) to understand the identified problems of human energy depletion, informing the design of the toolkit's strategies, techniques, frameworks, and resource recommendations. SDT principles can guide the design of customized solutions that align with the diverse needs of workers in Industry 5.0, ensuring that human-centric energy reinforcement is based on fulfilling these core psychological needs. The HumanEnerg Hotspot can utilize SDT's human-centric insights to ensure that

energy reinforcement strategies are not just operationally effective but also align with individual motivations and well-being. This makes the toolkit more sustainable and adaptable within different industrial contexts. By aligning the HumanEnerg Hotspot with SDT's principles of autonomy, competence, and relatedness, the toolkit can holistically address both the psychological and practical aspects of human energy reinforcement. SDT provides a theoretical foundation for designing interventions that not only alleviate stress but also foster long-term human energy sustainability within Industry 5.0.

3. Methodology

To ensure both scientific rigor and practical relevance firmly grounded in theory, this research combined qualitative practices of Design Science Research Methodology and Human-Centered Design (HCD) methodology in creating a human-centered artifact (toolkit).

This research found Design Science Research Methodology (DSRM) very suitable for the systematic creation of an artifact like the 'HumanEnerg Hotspot' toolkit while also incorporating empathy principles of the Human-Centered Design (HCD) methodology to enhance its effectiveness. Badke-Schaub et al. [47] asserts that the Human-Centered Design methodology serves as a critical link between academic research and the practical requirements of industry. According to [47], while Design Science Research (DSR) offers methods and tools to ensure the development of new products and services with the highest standards of usability, acceptance, and safety, it is crucial to understand the needs and desires of both current and future users. Additionally, the challenges posed by contextual variables that influence the product, process, as well as economic and ecological factors, are of paramount importance [47]. This is where Human-Centered Design (HCD) becomes essential as it addresses these contextual challenges and ensures that the products and services developed are not only functional but also aligned with user needs and environmental considerations.

While DSR Methodology focuses on the creation of innovative artifacts to address real-world problems, HCD places the needs and experiences of users at the center of the design process. This complementary blend enables comprehensive problem identification and solution-seeking techniques firmly grounded in both theory and practical applications. Design Science Research Methodology is a research methodology with origins in engineering and the sciences of the artificial, frequently applied in fields such as information systems, software engineering, and management [48]. Building on existing knowledge and thoroughly evaluating the suitability of research contributions, DSRM provides a structured set of guidelines that outline the approaches used to design and develop the toolkit [49–51]. The DSRM provides a better role understanding between research and the business world in the development of the toolkit, suggesting phases and steps and indicating where practitioners or researchers' participation is needed. Consistent with prior literature, it offers a nominal process model for conducting Design Science research and provides a mental framework for presentation and evaluation. The processes in DSRM consist of three main phases, problem identification, solution design, and evaluation, which can interrelate throughout the research process [51]. Human-centered design (HCD) is a strategic framework that emphasizes the importance of empathy, aligning processes with human engagement. It aids the understanding of the perspectives and experiences of the people who will be affected by a design, enabling the development of solutions that are effective, efficient, and satisfying [50]. Human-centered design is an iterative design approach that will be used to ensure that the tools in the "HumanEnerg Hotspot" toolkit are tailored to the needs and goals of the people they are designed for. This approach involves continuously gathering and incorporating feedback from users to improve the toolkit and ensure that it is effective, user-friendly, and relevant. As circumstances and situations change, the tools may need to change in their design to adapt to uncertainties. Considering the needs and perspectives of individuals from diverse backgrounds and with different abilities, it ensures that the tools in the toolkit are inclusive and accessible

to all [47]. Thus, HCD helps ensure that the "HumanEnerg Hotspot" toolkit is adaptable and flexible and can be easily customized to meet the specific needs and goals of different organizations and individuals.

4. Conceptual Development

The toolkit "HumanEnerg Hot Spot" can be defined as a comprehensive collection of tools, techniques, and strategies that provides organizations and individuals with the necessary resources to identify, analyze, and optimize human energy. The concept of its design is based on the central elements of strategies, methods, frameworks, and resource ideas, encompassing the full range of industrial engineering and management activities involved in the design and optimization of corporate processes. The strategies, methods, frameworks, and ideas within the toolbox are derived from already established theories and frameworks in management. Some instances among the numerous available ones are Root Cause Analysis, the McKinsey 7S model, and SWOT Analysis [52]. Moreover, the toolbox incorporates strategies and ideas that may have been adapted or newly developed during the course of this research. The technologies in the "HumanEnerg Hotspot" include modern information and communications technologies (ICTs) and other digital innovations associated with Industry 5.0 such as digital assistance systems. Besides the informational components, the toolbox also incorporates organizational elements. Their functions are to systematically arrange the vast array of techniques, tools, technologies, within the toolbox and to manage the intricacy of the expanding range of tasks in the field of industrial engineering and management. Related strategies are bundled together in related fields. The components of the 'Human Energy Hot Spot' correspond to the overarching design principles and enterprise processes, enabling a comprehensive and coherent framework. Figure 2 provides an overview of the core components in their overall context. The component choices, partly inspired by Human-Centered Design [53], Edward Deming's PDCA cycle [54] and the design thinking [55], have been tailored to suit the purpose of human energy reinforcement.

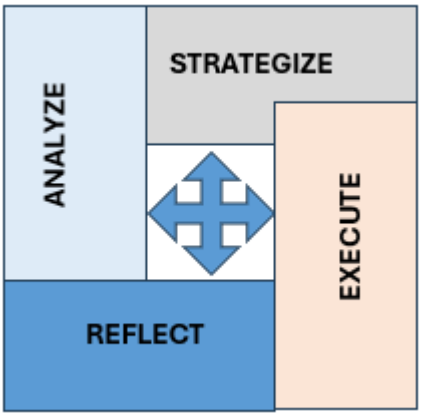

Figure 2. Core tool groups of the 'HumanEnerg Hot Spot' agile toolkit.

The tools in the HumanEnerg Hotspot are grouped under four major headings, which can be utilized in a cyclical fashion, interrelating with one another.

- 'ANALYZE' is a collection of tools designed to assess human energy levels and uncover the root causes of current and potential stress triggers along with their impacts. The word 'analyze' is a verb meaning 'to examine something in detail to gain a better understanding or draw conclusions'. This toolset is focused on analyzing both the environment and individuals to identify patterns that drain human energy. Operating in empathy mode, these tools enable the continuous analysis of various situations to better understand people in the context of energy-depleting circumstances. Tools in this group are required for observation, measurement, engagement, active listening, and analysis, helping to identify stress triggers and assess their severity.

- 'STRATEGIZE' is the process of devising, planning, and deciding an appropriate strategy or a right combination of strategies to mitigate identified human-energy-depleting issues. This tool collection houses a plethora of strategies that are researched solutions to many of the already identified stress triggers in the design of this toolkit. It incorporates tools in the form of 'STRATEGIES': plans, ideas, resources, frameworks, and methods that can be applied to mitigate the findings from the 'Analyze process'.
- The 'EXECUTE' group consists of tools used to implement the strategized plan, as determined in the 'strategize process' to mitigate an identified human-energy-depleting trend. This tool collection contains execution ideas for the solution strategies and concepts researched to address the identified stress triggers uncovered during the designing of this toolkit.
- Then, the REFLECT group features ideas for evaluating the effectiveness of human energy management and well-being strategies such as progress tracking templates and feedback surveys.
- The arrows in the middle section represent the Human-Centered Design (HCD) flow, emphasizing a continuous understanding of users' needs and empathy throughout the usage of all tools within each process group. This flow ensures that user-centered insights guide every stage of the design process, promoting solutions that are deeply aligned with human experiences and well-being.

The 'Human Energy Hot Spot' is designed for end user groups within the industrial engineering and management domains. Industrial engineering and management in this research involves both corporate administrative planning and the direct application of Human-Centered Design methodology. It emphasizes the importance of empathy and user research to understand the perspectives and experiences of the people affected by the toolkit design. This approach aims to develop effective, efficient, and satisfying solutions.

The creation of the 'HumanEnerg Hotspot' toolkit follows a specific roadmap, illustrated in Figure 3. The conceptual design includes the methodological framework (DSM and HCD) that will be applied to populate the toolkit, which is built using the databased approach. A prototype will be first designed and made available to industry practitioners and other stakeholders, built using open-source resources and designed to be interactive and user-friendly. It will allow users to interact with the elements of the prototype, enabling them to see and understand how the prototype will work and function in practice. The essence is to gather constructive feedback as users are encouraged to leave comments and suggestions. This feedback will provide valuable information and insights for the iterative development and evaluation of the toolbox, ensuring that it meets the user's needs and requirements.

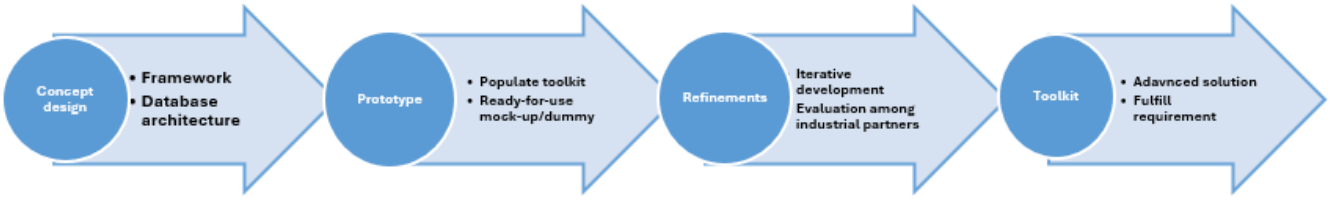

Figure 3. Roadmap for developing the 'HumanEnerg Hotspot' toolkit.

The roadmap anticipates the ongoing development and enhancement of the content and structure of the 'HumanEnerg Hotspot' toolkit, involving not only researchers but also end users and their actual production systems from an industrial consortium. This collaborative and inclusive approach will ensure that the toolkit is relevant, practical, and effective for the users and that it meets the needs and requirements of the industry. Iterative feedback loops will ensure that the toolbox is regularly reviewed and assessed by experts in the field, with their feedback and insights being incorporated into its design and development. The prototype's aim will be to pave the way for a market-ready toolkit capable of fulfilling all the requirements defined in Table 1 below.

Table 1. Conceptual specifications for the toolkit.

Group	Requirement
Structure	User-friendly interface Role-based access and interaction privileges Consistent and adaptable design Structures and interfaces for external contributions Support for common application processes, including keyword search, browsing use cases, editing, and adding content structures, with a focus on good usability and modern user interfaces.

5. Design of the Toolkit 'HumanEnerg Hotspot' with DSRM and HCD

The "Human Energy Hot Spot" itself is a toolkit designed for industrial engineering and management, containing strategies, frameworks, and ideas aimed at helping organizations mitigate the human energy crisis. This paper intends to implement the design science research process as illustrated by [51]. The research process is divided into three primary phases: "problem identification", "solution design", and "evaluation". Adapted from Offermann et al. [51], Figure 4 below illustrates the Design Science Methodology framework adopted in this research. These phases are not strictly linear and may interact with each other throughout the research process. Feedback from stakeholders during the evaluation plan may lead to modifications in the solution design. By allowing for flexibility and iteration between phases, the research process can be adapted to the specific needs and context of the project [51].

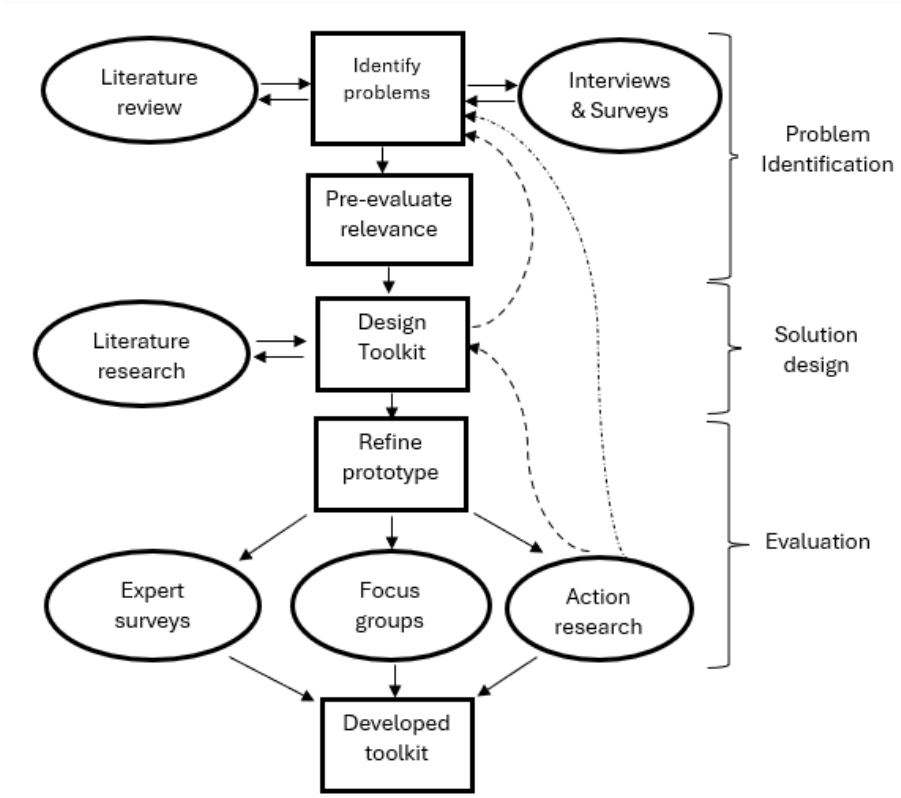

Figure 4. DSM framework applied for the design of the HumanEnerg Hotspot. Adapted from Offermann et al., 2009 [51].

5.1. Problem Identification

The problem identification phase as shown in the diagram above is structured to have the following steps: "Identify problem", "literature review", "expert interviews", and "pre-evaluation of relevance" [51]. Here, the specification of the identified problems is

decided and their relevance verified. For instance, problems identified should be in the domains of industrial engineering and management, human resource management, and, to some degree, in psychology. The research should aim to identify problems that are not overly specific and limited in scope but more generalized and commonly experienced by members of society who work across various industry domains. By expanding the focus of the problem, the research can have a more widespread impact and provide insights and solutions that are applicable to a larger number of individuals and organizations. In this phase, the current state of research on the identified problem areas are analyzed, providing a solid and essential foundation for the subsequent research process.

- Identify problem: The designing of the HumanEnerg Hotspot starts with identifying potential stress triggers from both within and outside the industry environment, for which strategies, frameworks, and other resource suggestions will be sought. Stress triggers can be identified by conducting an extensive review of existing literature and current practices to identify common stress triggers and factors contributing to human energy depletion. Data collected from expert interviews, surveys, and workshops with industry practitioners, and from observations of current and projected societal trends, can validate and expand on the identified issues [51].
- Literature review: Literature search is essential to review the current state-of-the-art strategies and resources related to the identified problem and to analyze potential theories, obstacles, and challenges for its resolution. Conducting literature research allows for a comprehensive understanding of the current state of knowledge in the field and helps identify key theories, frameworks, and evidence-based strategies for enhancing human energy. This will provide a solid foundation for the development of the toolkit and ensure that the strategies and resources included are grounded in the best available evidence.
- Expert interviews: Interviews with practitioners and experts in the field are conducted to identify both relevant and pressing issues as well as relief proposals. These include human-centered activities such as Empathy Mapping to understand employees' daily experiences, challenges, and stressors; Co-Creation Workshops that involve employees in the brainstorming and design processes; and also ensuring the toolkit features are inclusive and accessible and have a simplified design. This helps identify the specific needs related to energy depletion.

Pre-evaluate relevance:

In the designing of the human energy reinforcement toolkit, the pre-evaluation relevance phase is a critical step within Design Science Research Methodology (DSRM). This phase involves assessing the potential impact and importance of the identified problems and proposed solutions before fully committing to their use in the development and implementation of the toolkit. It ensures that the identified problems and proposed solutions are relevant and valuable to a broader audience. The results in this phase are used to inform the next phase in the development of the toolkit 'HumanEnerg hotspot', ensuring that it aligns with the needs and priorities of stakeholders. Here the identified problems are refined to ensure its relevance, utility, and understanding.

In contrast to the literature research conducted during the problem identification phase, the focus of this step should be on relevant scientific publications that specifically address the solution being developed. Here, the literature research conducted during the artifact design phase is more focused and targeted, with an emphasis on identifying evidence-based strategies and approaches for developing a solution.

5.2. Solution Design

In the second phase of the research process, the solution is designed. This phase is divided into two main steps: "artifact design" and "supporting literature research" [51]. After identifying a problem and pre-evaluating its relevance, the next step is to develop a solution in the form of an artifact such as the "HumanEnerg Hotspot" agile toolkit. The artifact design step involves creating the specific components and features of the toolkit,

such as the database, while the supporting literature research step involves conducting additional research to inform and support the design of the artifact. By combining these two approaches, the research team can develop a solution that is grounded in the best available evidence and has been tailored to the needs of end-users. The design artifact 'HumanEnerg hotspot' created via this research will be an agile toolkit, an online resource with lots of interactive components. It will include mechanisms for users to provide ongoing feedback about the effectiveness of interventions, as well as strategies for the continuous refining and improving of the toolkit based on user feedback and evolving needs.

5.3. Evaluation

Once the solution, in the form of a prototype, has reached a satisfactory level of development, the evaluation process begins. A detailed plan for the evaluation process is created. This process will involve multiple iterations, with feedback from users and stakeholders leading to modifications and improvements to the prototype [51]. In some cases, these iterations may involve revisiting earlier stages of the research process, such as the "identify problem" or "design artifact" phases, in order to ensure that the solution is aligned with the needs and priorities of stakeholders and is effectively addressing the identified problem [55,56]. Evaluation in this research will be conducted through the Action Research methodology to demonstrate practical applicability [57,58]. Additionally, various other methods could be employed depending on specific needs or circumstances. The methods could include prototyping and iterative design, surveys and questionnaires, focus groups, usability testing, heuristic evaluation, and user interviews [55–58]. The initial version could be evaluated via prototyping and iterative design. Surveys and questionnaires could be distributed to employees before and after implementing the toolkit to ensure that the toolkit fits the purpose. Usability tests can be performed to assess the user-friendliness and ease of use of the tools and resources in the toolkit [55,58]. Focus groups may be set up to gather collective insights and suggestions for improvement. With heuristic evaluation, experts will review the toolkit against established usability heuristics or a check list to identify potential design flaws and areas for enhancement. The evaluation process would employ Action Research and follow a structured approach. It would first identify the specific aspects of the toolkit to be evaluated, then analyze and reflect on the collected information to identify areas for improvement. In this phase, the "HumanEnerg Hotspot" toolkit would be assessed in a real-world setting, such as in industries, in order to collect data on its effectiveness. Finally, these insights would be used to refine the prototype, enhancing the toolkit's design.

Navigation in the toolkit can be done in two ways: by clicking on the core tool components 'analyze', 'strategize', 'execute', or 'reflect' or by utilizing the search bar and searching for 'stress triggers.' For instance, as shown in Figure 5 below, a search for "Artificial Intelligence (AI)" as a stress trigger should highlight the most critical stress-inducing issues caused by AI advancements, such as job insecurities. This will be followed by suitable strategies, techniques, methods, or resource suggestions that can be applied in industry to boost human energy and productivity for each issue. The toolkit will continue to evolve post-deployment as ongoing feedback from its use in various geographic and industry settings will provide new insights into stress triggers and mitigating strategies.

Figure 5 above provides a general overview of how the tools in the HumanEnerg Hotspot will be accessed. The tools will be accessed in two ways: by clicking the core tool group buttons from the user interface to explore various tools within a group or by conducting a search based on stress triggers. The diagram above demonstrates access to the tools associated with a specific stress trigger. To illustrate, a search by the stress trigger named "Stress Trigger I" (e.g., "AI") will retrieve all problems in the database related to 'Stress trigger I'. In our instance, all problems related to 'the impact AI (Artificial Intelligence) can have on human energy' will be retrieved. The user will then scan through the problem list to identify which problem instance best represents their concerns. Clicking on each problem should reveal various tools in the form of strategies, techniques, methods,

and resources, compiled through research and saved in the general repository to help reinforce human energy despite the increase in the stress causative factors within the employee's environment. The diagram above illustrates how users access the compiled tools to address three specific problems stemming from a single 'stress trigger' or identified issue related to human energy depletion.

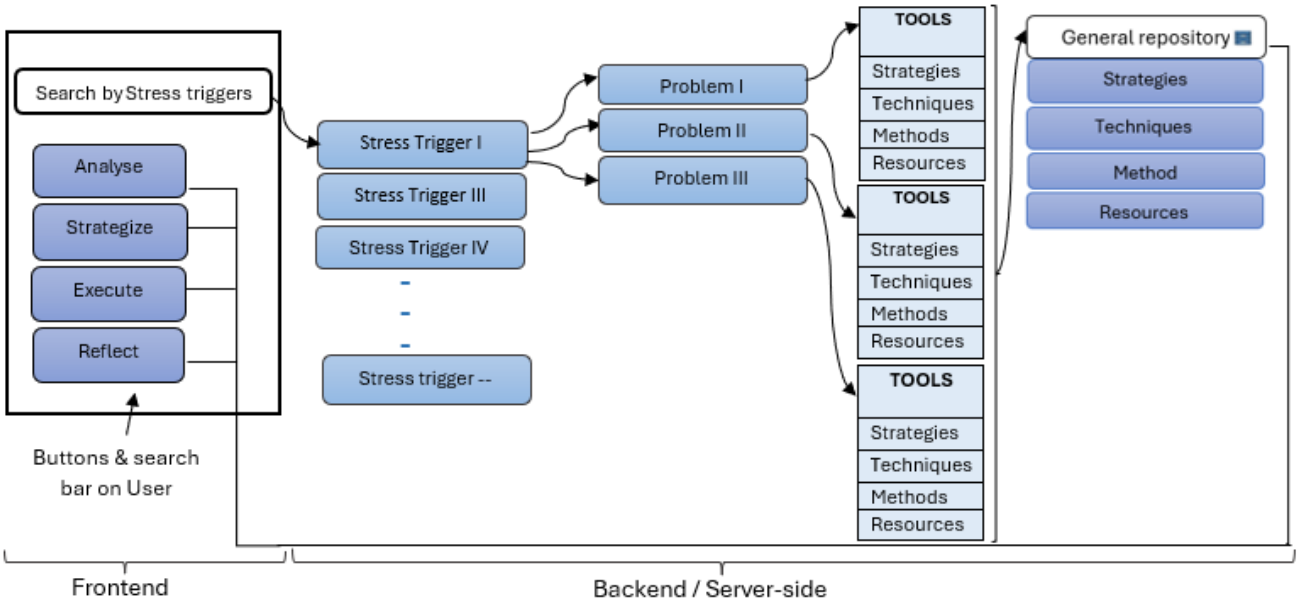

Figure 5. Data retrieval diagram for the HumanEnerg toolkit.

Building on existing knowledge and thoroughly evaluating the suitability of research contributions, DSRM provides a structured set of guidelines that outline the approaches used to design and develop the toolkit [48,49]. Human-Centered Design (HCD) is being applied in every phase of development: in problem identification, solution design, and evaluation. The data collection process, prototyping, and usability testing will ensure that the tools in the toolkit are truly tailored to the needs and goals of its users. Serving as a blueprint for planning and organizing the research processes, the derivative of DSRM and HCD ensures close empathic cooperation between researchers and practitioners throughout the process. The developed prototype will be refined iteratively based on feedback from user testers and industry experts. This feedback, collected through expert surveys and focus groups and balanced with a literature review, will then be incorporated to improve the toolkit's conceptual design. The toolkit will have been designed to be agile, enabling users to update it with tested strategies that work for them, serving as a repository for effective strategies.

6. Conclusions

This paper significantly advances the theoretical understanding of "Industry 5.0" by integrating the concept of human energy reinforcement as a key human-centric component of industrial evolution. The paper aligns with the European Union's vision for industry to positively impact society, placing worker well-being at the center of the manufacturing process. It extends existing human-centered research by drawing on psychological and organizational behavior frameworks such as the Cognitive–Transactional Model and Self-Determination Theory (SDT). This approach will ensure that the toolkit is grounded on a strong theory base, informed by the latest research and best practices in the field. This paper has contributed to the evolving discourse on human-centricity in Industry 5.0 and its approach to mitigating the 'human energy crisis', highlighting the critical need to align industrial practices with societal well-being.

This research introduces the HumanEnerg Hotspot, an agile toolkit designed to provide practical strategies for reinforcing human energy within industrial settings. This toolkit offers adaptable methods and frameworks to combat human energy depletion, particularly mental fatigue and emotional exhaustion. Developed using Design Science Research Methodology (DSRM) and Human-Centered Design (HCD), the HumanEnerg Hotspot follows a three-phase approach: problem identification, solution design, and evaluation. It is structured under four major categories—Analyze, Strategies, Execute, and Reflect—which interact cyclically to ensure continuous improvement and adaptation to user needs, guided by Human-Centered Design (HCD) principles. The toolkit is a robust and versatile collection of resources, strategies, and tools, aimed at empowering industries to build employee resilience and navigate the growing stressors within and outside the industrial environment. By reinforcing human energy, the toolkit directly impacts societal health and productivity, aligning industrial efforts with broader socio-economic goals.

The paper acknowledges several limitations. Firstly, the effectiveness of the toolkit may be constrained by the variability in how individuals interpret and respond to the same prompts or assessments. Additionally, there is potential variability in how industries of different sizes and sectors adopt and apply the toolkit's recommendations.

Future research could explore cross-cultural studies to examine the applicability and effectiveness of human energy reinforcement strategies in diverse cultural contexts. Additionally, longitudinal studies could investigate the impact of the toolkit's deployment on organizational performance over time. Research could also focus on the correlation between subjective improvements in employee well-being and tangible organizational outcomes, such as productivity, job satisfaction, and retention rates. These insights would help improve the applicability and effectiveness of the toolkit, facilitating its seamless adoption and implementation by industries to enhance productivity and build resilience against human energy-depleting circumstances.

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