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# The Supportive Legislative Approach to Enabling Sustainable Energy Storage Technologies in Neom

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**Abstract**

**Introduction** :The study centered on the legislative strategy to endorse sustainable energy storage in Neom, underscoring its significance in realizing carbon reduction targets. It stressed the necessity for well-defined goals incorporated into a legislative framework, synchronized with precise timelines and government priorities. Within the Kingdom of Saudi Arabia, notable advancements have been achieved in the field of energy transition, specifically in initiatives promoting energy efficiency and sustainable energy. The swift expansion of renewable energy projects is pivotal, given the economic and environmental challenges faced by the nation.

**Objectives**: The Kingdom of Saudi Arabia continues to grapple with future challenges. State-level energy policies possess the potential to propel sustained technological progress by initiating novel ventures and effectively enhancing industrial applications via the establishment of enduring mechanisms for cost reduction. Moreover, there is a pressing need for a robust legislative framework and a supportive governmental milieu to sustain the upsurge in investments in renewable energy. The capability to react to crises will augment the fortitude and resilience of sustainable energy systems.

**Methods**: This study employs a theoretical approach involving the description and analysis of the current legislative framework that supports sustainable energy storage technologies in Neom. The study relies on a combination of primary and secondary sources, along with scientific publications, to underpin the analysis and derive conclusions.

**Results**: In Neom, Saudi Arabia is actively striving to enhance the utilization of green energy through the adoption of effective legislative measures. These regulations serve to incentivize increased investments and create promising investment prospects. Additionally, energy storage technology is seen as a comprehensive and multidisciplinary model, playing a valuable role in the broad industrial development occurring in Neom. To attain the nation's objectives of reducing carbon emissions, it is crucial to establish clear and specific goals within a legislative framework, and diligently work towards achieving them within defined timeframes, all while considering governmental priorities.

**Conclusions**. The challenge of green energy in Saudi Arabia isn't primarily a resource constraint but rather stems from inadequate legislation regarding sustainable energy technologies. Legislative policies for clean energy alternatives are a fundamental aspect of the energy transition strategy

**Keywords**: Legislative methodology, Energy Storage، Sustainable Technologies, NEOM

## 1. Introduction

Renewable energy[1] is a pivotal driver towards the transition to a sustainable energy systemGenerating electricity ,[2] from renewable sources has become a globally competitive and highly regarded endeavor[3]. It is considered one of the key objectives of the Sustainable Development Goals (SDGs) for 2030, a set of goals established by world leaders, with the protection of the planet standing as one of the most significant among them[4].

In the Kingdom of Saudi Arabia, and within the scope of the NEOM project[5], sustainability of the electrical energy systems[6] will heavily incorporate the use of renewable energy sources to produce power[7],Some of these sources, such as wind and solar energy, exhibit intermittent behavior, making it challenging to predict their energy output, leading to high fluctuations in power generation. Consequently, there will be a need for energy storage devices at different locations within the energy system to balance the mismatch between renewable energy generators and consumption, as well as to store surplus energy from renewable sources for later use during periods of low generation[8].

As for innovative legislation concerning various storage technologies and how they can be utilized in a sustainable energy system in NEOM, expertise will be required in numerous fields within the project. This ranges from economics to energy storage, all under a legislative framework that ensures innovation and development in sustainable energy storage technologies.

Renewable energy represents one of the processes that can significantly improve the quality of life on our planet by reducing greenhouse gas emissions through the implementation of eco-friendly technologies. Renewable energy is free, constantly available, and derived from natural resources; hence, it is logical to apply such technologies not only for cost savings but, more importantly, to save our planet. However, integrating renewable energy technologies into a country's energy mix is a complex and multi-dimensional process. It is challenging and requires such a socio-technical transformation, including changes in current technological and regulatory systems, time-consuming and costly infrastructure investments, the implementation of energy-supportive policies and legislation, and efforts to increase awareness within the society.

## 2. Objectives

### A. Concept of Potential Legislation for Sustainable Energy Storage Technologies.

Energy storage is a fundamental technology for energy conversion, aiming to enhance sustainable development in the energy storage industry[9]. The concept of sustainable energy storage technologies is associated with overall innovations and modern techniques that sustainably manage energy usage during times of scarcity. The strategy of clean energy storage significantly contributes to the energy transition process[10],The Kingdom of Saudi Arabia has a significant climate impact, and therefore, it is advisable to implement policies and measures for energy transition in a systematic way to achieve more efficient energy use[11]. Having flexible and sufficient legislations and policies ensures security and stability in implementing a sustainable energy matrix, which represents a shared challenge for the region. This response cannot solely rely on economic issues, but also social and environmental ones. The transition from fossil fuels to renewable energies is inevitable, which necessitates the need for energy storage planning to respond to this reality[12].

The necessity to reduce carbon[13] levels for environmental protection is an essential part of the energy transition. According to prevailing legislation, energy storage is deemed fundamental in safeguarding the human right to sustainable and affordable energy[14], ensuring safe, sustainable, and modern energy for all. Having flexible regulations concerning energy issues requires giving due attention to regulatory frameworks implemented by countries to enhance energy transition. Additionally, there is a need to harmonize the efforts of both public and private sectors to prioritize environmental concerns and promote efficient energy use.

Energy transition policy should involve both the private sector and civil society to achieve the common goal of reducing greenhouse gas emissions[15]. It requires abandoning development models that misuse environmental systems and instead promote technological innovation and renewable energies. These have three potentials: meeting energy demand for various individuals and sectors, contributing to climate change mitigation, resulting in social, economic, and environmental benefits[16].

In addition, it serves as an alternative to achieving sustainable development goals, collectively contributing to reducing inequalities and discrimination related to the lack of access to energy under sustainable conditions. Energy storage represents a possibility that supports its supply, sustainability, and accessibility by allowing more accurate and efficient management of all variables involved in system equilibrium, such as time, supply, demand, and technical operating conditions of networks. Considering new technologies as a fundamental element for the energy transition is crucial[17].

Energy storage and social responsibility are considered safety valves for what can be called "energy poverty" and the problems that arise from it. Therefore, organizations and international agreements have given great attention to the social responsibility for energy sector development. This is due to the need for unified efforts to achieve the set goals, which are not solely the responsibility of nations but also organized communities and economic factors. The current status of renewable energies globally and locally, along with the challenges they face, sometimes necessitate the establishment of energy legislation that includes not only binding legal sources but also non-binding laws.

It is worth mentioning that energy storage, both globally and locally, is witnessing rapid and significant growth[18] However, various challenges persist, including the following:

- The technology's size, cost, and lifespan cannot fully meet application requirements, and some fundamental technologies cannot be mastered entirely[19].
- The safety system of energy storage products still requires improvement.
- The energy storage market needs further advancements[20].

**B . Aligning NEOM's Vision with Sustainable Technology Empowerment Targets**

Energy policy and regulation are critical factors in implementing renewable energy and managing natural resources. They prioritize supporting reliable and sustainable access to energy for any global community[21]. Consequently, the development of policies, legislation, and institutional frameworks is of paramount importance for the sustainability of renewable energy. Countries aiming to encourage investments must focus on creating supportive policies and regulatory environments to promote sustainable energy[22]. Enhancing the energy sectors is crucial in achieving the seventh goal of the Sustainable Development Goals[23], which is to develop a suitable environment first. Establishing policies and regulations that support their objectives is vital. In this context, sustainability represents a critical turning point in the global development agenda. Therefore, international legislation should encourage countries to accelerate the transition to renewable energy[24].

Energy is essential for all economies worldwide and is a critical factor in achieving long-term development[25]. Supporting the development of renewable energy is facilitated through energy policies and regulations[26] ,Energy policy and regulation are of utmost importance for countries to achieve the seventh goal of the Sustainable Development Goals[27], enhance new investments, and promote sustainability in their energy sectors[28]. Severe global warming, climate change, and natural disasters pose unprecedented risks to humanity. The magnitude of these dangers reflects the scale of global and local challenges we face. These challenges represent some of the most significant threats to human health in history. Environmental destruction, pollution, and habitat depletion are natural consequences of societal advancement, using this framework, sustainable energy can be provided to meet current needs without compromising the ability of future generations to meet their development and prosperity requirements. Therefore, international policymakers are encouraged to develop solutions to facilitate the transition towards sustainable technology applications and strategies to enhance climate mitigation, adaptation, and environmental preservation[29],It is indeed unfortunate to believe that the promotion of renewable energy sources and natural resource management will not be strongly emphasized within the NEOM project[30].

**B.1 The concept of energy sustainability.**

Countries are increasingly integrating advanced policy frameworks into their regulatory systems to achieve sustainable energy systems. Therefore, a robust legislative framework and supportive governance context are essential to maintain the growing investments in renewable energy. Energy storage will play a crucial role in ensuring resilience during times of crisis, making sustainable energy systems more robust. It is important to note that systems differ from one nation to another and from one political system to another[31]**.**

In this context, increasing evidence suggests that such sustainable development requires institutional reforms and cohesive development policies in all countries[32]. The term sustainability has evolved beyond being merely a scientific, ethical, and environmental issue; it has become a descriptor of the stance and perspective on what sustainable development can look like[33]What makes equitable development beneficial for all parts of the world?"[34]

The environmental issues have become more urgent, requiring new systematic solutions. Therefore, we see that the overarching problem to be considered is the sustainability of sustainable development.[35]" In reality, these challenges will positively impact human life, sustainable growth, economic opportunities, and intergenerational equality. All of this necessitates the creation of a new type of economy that connects these goals. In this regard, this economy will be based on coherence and interconnectedness between the fundamental economic, environmental, and social dimensions of development, determining its long-term viability. It relies on environmental security and social responsibility to achieve a general balance based on a systematic approach that gives meticulous attention to the environment and governance when making investment decisions in the energy storage sector. This will lead to increased long-term investment in sustainable economic[36] activities and projects and a reevaluation of the fundamental principles of sustainable development[37].

**B.2 Energy storage as a mechanism for achieving energy sustainability.**

Energy, in any form, is a fundamental commodity on a global level. It is the most common consumable commodity and remains a crucial element in development worldwide[38]. Energy comes in various forms, although it can be broadly categorized into two types: primary and secondary energy, Primary energy refers to energy sources that involve only extraction or capture, with or without cleaning or classification, before the energy can be converted into heat. Examples of primary energy sources include wind energy and solar energy, which occur naturally in the environment.

On the other hand, secondary energy forms encompass all types of energy that result from converting primary energy through energy conversion processes. These secondary energy forms are more convenient for human use and are commonly known as energy carriers. One of the prominent examples of secondary energy forms is electricity[39],As a result of emissions from fossil fuels, which pose a global environmental threat due to their contribution to the phenomenon of global warming, significant efforts have been made over the years to mitigate carbon dioxide emissions and reduce their environmental impacts. This has been achieved through the development of new and innovative energy conversion technologies and improving the efficiency of existing energy conversion techniques[40], Furthermore, reducing energy waste by storing it for future use has a significant impact on reducing carbon dioxide emissions[41]. The need to balance the mismatch between the energy supplied to the grid and the actual energy used from the grid through energy storage of surplus energy is of utmost importance in achieving a low-carbon economy, in light of this background, we believe that energy storage is essential in modern energy supply chains as it helps to mitigate leakage and improve efficiency. As a result, energy storage has recently attracted the attention of governments, stakeholders, researchers, and investors, as it can be utilized to enhance the performance of energy supply chains.

**B.2.1 Motivations for Energy Storage**

Energy storage is a crucial link in the energy supply chain as there is no system that is 100% thermodynamically efficient. Energy losses in the form of heat are typically dissipated into the environment, this wasted heat is considered a valuable resource that, if captured and stored, can serve as useful energy resources. Therefore, energy storage will play a significant role as the world transitions to a low-carbon economy. Energy is produced from renewable resources[42]. One of the main challenges facing most renewable energy sources, especially solar and wind energy, is their intermittent nature, which makes them unreliable for obtaining a consistent power supply.[43]

Through the concept of energy storage, these renewable resources can become reliable and constant energy sources. This can be achieved by storing the excess energy generated when renewable resources are available and reusing the stored energy when the renewable resources are not available.[44]

**B.2.2 The benefits of energy storage.**

The increasing interest in electrical energy storage is largely attributed to the tremendous growth in intermittent renewable energy sources such as wind and solar power, in addition to the global drive towards decarbonizing the energy economy[45]. However, the existing electrical grid systems worldwide are not equipped to handle widespread integration of intermittent energy sources without experiencing severe disruptions in the grid,[46]It is generally agreed that penetrating more than 20% of intermittent renewable energy sources can significantly destabilize the grid system. However, widespread electrical energy storage systems can mitigate many of the inherent shortcomings and inefficiencies in the grid system, enhance grid reliability, facilitate seamless integration of intermittent renewable sources, and effectively manage power generation[47],Electrical energy storage provides two important advantages. Firstly, it decouples electricity generation from consumption, making it easier to manage supply and demand. Secondly, it enables opportunities for distributed storage in local grids or microgrids, significantly improving grid resilience and enhancing energy security, Currently, there is only around 170 gigawatts of installed storage capacity worldwide, with over 96% of it being pumped hydro storage, which is limited by location and not widely available. Therefore, there is a need for a diverse range of technologies to meet the diverse and widespread demands for large-scale electrical energy storage[48].

**C. Analysis of the current legislative situation in the Kingdom to enable sustainable technologies.**

In addition to the global efforts to combat climate change[49] and accelerate the necessary energy transition[50], the Kingdom of Saudi Arabia is driven by other social and economic factors to develop alternative energy sources. The potential[51] for renewable energy[52] in Saudi Arabia is remarkable, particularly solar and wind energy, given its geographical location within the "sunbelt." There is a matching between peak sun hours and peak electricity demand, Furthermore, the development of alternative energy sources will help meet the increasing local energy demand in the Kingdom resulting from general economic development, population growth, and improving living standards. Moreover, the development of alternative energy sources aligns with Saudi Vision 2030, which aims to transition towards renewable energy by significantly reducing reliance on oil[53].

With this context, Saudi Arabia has actively participated in global efforts to address climate change and manage the energy transition on both international and domestic levels. The Kingdom of Saudi Arabia ratified the United Nations Framework Convention on Climate Change (UNFCCC), an international environmental treaty, by joining on December 28, 1994, and became a party to the Kyoto Protocol on January 31, 2005. In December 2015, when the parties to the UNFCCC reached a historic agreement, the Paris Agreement[54], to combat climate change and accelerate and intensify actions and investments necessary for a sustainable low-carbon future, Saudi Arabia ratified the Paris Agreement on November 3, 2016.

In April 2021, Saudi Arabia joined the "Net Zero Producers Forum" alongside the United States, Canada, Norway, and Qatar – together responsible for 40% of global oil and gas production. The forum aims to develop "realistic net-zero emission strategies," including methane reduction, promoting circular carbon economy approaches, and developing and deploying clean energy technologies, carbon capture, utilization, and storage, diversifying from hydrocarbon revenue, and other measures that align with each country's national circumstances at the local level, In addition to making specific national contributions, Saudi Arabia has adopted various goals and strategies to address climate change and accelerate energy transition. These include state initiatives in energy efficiency, renewable energy, nuclear energy, and water energy.

## 2. Methods

This study employs a theoretical approach involving the description and analysis of the current legislative framework that supports sustainable energy storage technologies in Neom. The study relies on a combination of primary and secondary sources, along with scientific publications, to underpin the analysis and derive conclusions.

## 3. Results

- Effective legislation supporting green energy in Neom boosts investments and offers investment prospects.
- Energy storage technology serves as a comprehensive, interdisciplinary model, contributing significantly to Neom's broad industrial development.
- The attainment of carbon emission reduction objectives hinges on establishing clear goals within a legislative framework and achieving them within specified timeframes, while considering governmental priorities.

## 4. Discussion:

Within the NEOM project framework, Saudi Arabia is actively striving to increase the adoption of green and sustainable energy sources. The development of effective legislative policies is considered a crucial component in achieving this objective. These legislative policies play a vital role in stimulating investments and creating a conducive environment for companies and investors operating in the green energy sector. As a result of these policies, green energy projects become economically viable while maintaining environmental sustainability.

Furthermore, energy storage technology plays a prominent role in stabilizing the national electricity grid, especially concerning energy sources like solar and wind, which exhibit fluctuations in energy production. Therefore, the focus should be on advancing energy storage technology and establishing the appropriate legislative policies that facilitate the efficient utilization of these technologies.

Energy storage technology represents a comprehensive and multidisciplinary model, significantly contributing to the extensive industrial development in NEOM. This technology enables the storage of renewable energy for use when needed, reducing energy production fluctuations and enhancing sustainability.

One notable aspect of energy storage technology is its extensive diversity in types and methods, including battery storage, hydrogen storage, thermal energy storage, and more. This diversity allows NEOM projects to leverage tailored technological solutions to meet their unique needs.

Furthermore, energy storage technology greatly improves the efficiency of the electrical system, reducing the costs associated with energy production and distribution. This not only promotes environmental sustainability by reducing emissions but also fosters economic sustainability by offering valuable investment opportunities.

However, the main challenge lies in establishing an effective legislative framework that supports the implementation and sustainable development of this technology. It is essential to enact regulations and policies that encourage investment in energy storage and provide the necessary oversight to ensure system safety and sustainability.

In summary, energy storage technology plays a pivotal role in achieving industrial growth and sustainability goals in NEOM, embodying a sustainable reliance on renewable energy sources and a commitment to environmental preservation. The achievement of carbon emission reduction objectives within NEOM relies heavily on the establishment of precise and well-defined goals within a legislative framework. These goals must align with specific timelines and be in harmony with the government's top priorities. This approach is crucial for ensuring that the reduction of carbon emissions becomes a central focus of NEOM's sustainable development strategy.

Setting clear and specific objectives within a legislative framework provides a roadmap for action, ensuring that NEOM's energy initiatives are not just aspirational but backed by tangible plans. It offers a structured approach to addressing the pressing issue of carbon emissions and helps track progress toward sustainability goals.

Moreover, this legislative framework can serve as a catalyst for investment in green technologies and renewable energy sources within NEOM. It provides the regulatory stability and certainty that businesses and investors seek when considering sustainable energy projects. As a result, it can attract substantial investments and partnerships, further accelerating NEOM's progress towards carbon reduction targets.

Additionally, aligning these goals with government priorities underscores the commitment of NEOM's leadership to environmental sustainability. It signals that carbon reduction is not merely an environmental concern but a fundamental element of NEOM's overarching development strategy. This alignment can foster collaboration between government entities, businesses, and the community, creating a coordinated effort to tackle carbon emissions effectively.

In conclusion, the integration of clear objectives within a legislative framework is essential for NEOM's success in reducing carbon emissions. It not only provides a structured path for action but also attracts investments, fosters collaboration, and underscores NEOM's dedication to environmental sustainability.

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