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In order to obtain an academic master's degree in
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Titled:

The Impact of Public-Private Partnerships on Energy Transition Through Grid Software

Case Study of Siemens Algeria

Submitted by:	**Jury Members:**	**Supervised by:**
ELAGOUNE Abir	Pres.EL MOKRETAR Lamia Exam.BENHIDJEB Asmah Taoues	Pr. ZEROUTI Messaoud

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ABSTRACT

This study aims to understand the impact of public-private partnerships (PPPs) on the energy transition, with particular focus on the role of Siemens' grid software in enabling cleaner energy sources and the decarbonization of energy infrastructure. A quantitative methodology was adopted through an online questionnaire. Data were collected from 86 respondents, of which 70 met the eligibility criteria after filtering. The collected data were analyzed using principal component analysis (PCA) and linear regression via SPSS, Excel Stat, and JASP.

The findings reveal that grid software solutions significantly improve the efficiency of energy transition efforts, and that PPPs have a positive indirect influence on energy transition through their contribution to grid software development. However, the direct effect of PPPs on grid software development, as well as the moderating role of regulatory and financial challenges, were found to be statistically insignificant within the tested model.

Keywords: Energy transition, Public-private partnerships, Grid software, Siemens, Infrastructure decarbonization.

RÉSUMÉ

Cette étude vise à comprendre l’impact des partenariats public-privé (PPP) sur la transition énergétique, en mettant particulièrement l’accent sur le rôle des logiciels de réseau développés par Siemens dans la promotion des sources d’énergie plus propres et la décarbonisation des infrastructures énergétiques. Une approche quantitative a été adoptée à travers un questionnaire en ligne. Les données ont été collectées auprès de 86 répondants, dont 70 ont satisfait aux critères de filtrage. Les analyses ont été réalisées à l’aide de l’analyse en composantes principales (ACP) et de régressions linéaires via SPSS, Excel Stat et JASP.

Les résultats révèlent que les solutions logicielles pour les réseaux intelligents améliorent significativement l’efficacité de la transition énergétique, et que les PPP exercent une influence indirecte positive sur cette transition en contribuant au développement de ces logiciels. En revanche, l’effet direct des PPP sur le développement des logiciels, ainsi que le rôle modérateur des contraintes réglementaires et financières, se sont révélés statistiquement non significatifs dans le modèle testé.

Mots-clés : Transition énergétique, Partenariats public-privé, Logiciels de réseau, Siemens, Décarbonisation des infrastructures.

الملخص

تهدف هذه الدراسة إلى فهم تأثير الشراكات بين القطاعين العام والخاص (PPP) على عملية الانتقال الطاقي، مع التركيز بشكل خاص على دور برمجيات الشبكات الكهربائية التي طورتها شركة سيمنس في تسهيل استخدام مصادر الطاقة النظيفة وتسريع إزالة الكربون من البنية التحتية للطاقة. تم اعتماد منهج كمي من خلال استبيان إلكتروني، وقد تم جمع البيانات من 86 مشاركًا، منهم 70 استوفوا شروط التصفية. تم تحليل البيانات باستخدام تحليل المكونات الرئيسية (PCA) والانحدار الخطي من خلال برامج SPSS و Excel Statو JASP.

أظهرت النتائج أن حلول برمجيات الشبكة تساهم بشكل ملحوظ في تحسين كفاءة الانتقال الطاقي، وأن الشراكات بين القطاعين العام والخاص تؤثر بشكل غير مباشر وإيجابي على الانتقال الطاقي من خلال مساهمتها في تطوير هذه البرمجيات. ومع ذلك، فإن التأثير المباشر لهذه الشراكات على تطوير البرمجيات، وكذلك الدور التعديلي للتحديات التنظيمية والمالية، لم يكن ذا دلالة إحصائية في النموذج المُختبر.

الكلمات المفتاحية: الانتقال الطاقي، الشراكات بين القطاعين العام والخاص، برمجيات الشبكة، سيمنس، إزالة الكربون من البنية التحتية.

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LIST OF ABBREVIATIONS, INITIALISMS, AND ACRONYMS

ACP : Analyse en Composantes Principales (Principal Component Analysis)
ANOVA: Analysis of Variance
β: Beta Coefficient
DW: Durbin-Watson
ET: Energy Transition
Excel Stat: Excel Statistics Add-in
GS: Grid Software
H1, H2, H3, H4: Hypothesis 1, 2, 3, 4
JASP: Jeffrey’s Amazing Statistics Program
KMO: Kaiser-Meyer-Olkin Measure
PCA: Principal Component Analysis
PPP: Public-Private Partnership
R^2: Coefficient of Determination
RMSE: Root Mean Square Error
Sig.: Significance Level (p-value)
SPSS: Statistical Package for the Social Sciences
VIF: Variance Inflation Factor

INTRODUCTION

The global urgency to address climate change and reduce greenhouse gas emissions has placed energy transition at the forefront of national development strategies. As countries move toward sustainable energy systems, the challenge lies not only in expanding renewable energy capacity but also in modernizing the digital infrastructure that supports energy production, distribution, and consumption. In this context, Public-Private Partnerships (PPPs) have emerged as a vital strategic tool, bridging public policy ambitions with private sector innovation and investment (Raghutla & Kolati, 2023; Casady et al., 2024).

In developing countries such as Algeria, structural constraints, limited public financing, and regulatory uncertainty hinder the effective implementation of energy transition programs (Wang et al., 2022). While Algeria has launched a national renewable energy program targeting 22 GW of capacity by 2030, progress has been slow due to centralized governance, inadequate infrastructure, and insufficient digitalization of the grid. Siemens, as a global leader in smart grid technologies, has played an increasingly important role in this space through its partnerships with Algerian public actors such as Sonelgaz. This raises important questions about how PPPs can accelerate energy transition efforts via digital grid solutions.

1. Research Context and Problem Statement

1.1.Research Questions

This study is guided by the following central research question:

How do Public-Private Partnerships (PPPs) influence energy transition in Algeria, particularly through the deployment of grid software solutions provided by Siemens?

To further refine this inquiry, the following sub-questions are posed:

- What is the direct impact of PPPs on the development of grid software?
- How does grid software contribute to the efficiency of the energy transition?
- Do PPPs indirectly support the energy transition by enabling grid software deployment?
- How do regulatory and financial challenges moderate the effectiveness of these mechanisms?

1.2.Hypotheses

Based on the literature and conceptual model, the following hypotheses are proposed:

H1: Public-Private Partnerships have a positive impact on grid software development.

H2: Grid software solutions improve the efficiency of energy transition initiatives.

H3: PPPs positively influence energy transition through grid software deployment.

H4: Regulatory and financial challenges moderate the effectiveness of PPP-driven grid software solutions.

1.3.Research Objectives

The primary objective of this study is to assess the impact of PPPs on Algeria’s energy transition through the implementation of grid software solutions. More specifically, the research aims to:

- Evaluate the role of PPPs in enabling grid software development.
- Analyze how grid software contributes to renewable integration and grid efficiency.
- Measure the indirect effect of PPPs on energy transition through software deployment.
- Examine how regulatory and financial barriers affect the effectiveness of these mechanisms.

2. Research Relevance

2.1.Theoretical Relevance

Despite extensive international research on the benefits and risks of PPPs in the energy sector (Ugwu et al., 2024; Sun et al., 2020), few studies have investigated the intersection of PPPs and smart grid software in the context of emerging economies. This research contributes to the academic debate by offering a localized, empirical analysis of how collaborative governance and digital technology intersect to support energy system transformation. It also expands the theoretical framework linking PPP effectiveness to technological adoption and transition outcomes in under-researched contexts like Algeria.

2.2.Managerial Relevance

From a practical perspective, this study offers actionable insights for both public institutions (e.g., the Ministry of Energy, Sonelgaz) and private sector actors (e.g., Siemens, energy tech providers). Understanding the operational dynamics and limitations of PPPs can help improve contractual design, risk management, and technological alignment. The findings also inform decision-making on how to better integrate software-based energy solutions in national energy strategies, particularly under financial and regulatory constraints.

3. Research Methodology

To investigate the stated hypotheses, this study adopts a quantitative research approach based on an online structured questionnaire targeting professionals involved in Algeria's energy transition, including staff from Siemens, Sonelgaz, and other key stakeholders. The dataset includes responses from 70 qualified participants.

The analysis combines descriptive statistics, Principal Component Analysis (PCA), and linear regression techniques, using SPSS, Excel Stat, and JASP. Reliability and validity tests were conducted to ensure robustness. The research also includes contextual qualitative elements, such as internal project reports, to triangulate the findings and strengthen empirical grounding.

4. Thesis Structure

This thesis is structured into three main chapters:

Chapter I – Literature Review and Conceptual Framework: Reviews the theoretical foundations of PPPs, grid software, and energy transition; presents the conceptual model and research hypotheses.

Chapter II – Methodological Framework and Research Context: Details the research design, data collection, sampling strategy, and analytical methods; introduces the energy sector in Algeria and Siemens' role.

Chapter III – Results and Discussion: Presents the empirical findings, tests the hypotheses, and discusses their implications in light of the literature and the Algerian policy context.

The thesis concludes with key recommendations, limitations of the study, and avenues for future research.

CHAPTER I: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

This chapter aims to provide a comprehensive foundation for understanding the impact of public-private partnerships (PPPs) on energy transition, with a particular focus on the role of Siemens' Grid Software in facilitating cleaner energy sources and infrastructure decarbonization. Given the growing global emphasis on sustainable energy solutions, analyzing the collaboration between private technology providers and national energy entities is crucial for identifying best practices and potential challenges in energy transition efforts. By dedicating an entire chapter to this study, we ensure a thorough exploration of key theoretical perspectives and conceptual models relevant to the research.

This first chapter is structured into two sections. The first section presents the literature review. The second section is dedicated to the conceptual framework of our research, where we outline the main concepts mobilized, the research model, and the hypotheses proposed and to be tested in the practical chapter.

I. LITERATURE REVIEW

Several studies have examined the role of Public-Private Partnerships (PPPs) in energy transition using diverse methodologies. Some have employed econometric models to analyze financial feasibility and investment risks, utilizing historical financial data and policy impact assessments**.** Others have applied comparative policy analyses**,** evaluating regulatory frameworks through energy consumption metrics and legal structures**.**

Certain studies have conducted stakeholder surveys, involving government representatives, private investors, and energy firms, to identify success factors and barriers. Others have implemented simulation models, incorporating grid stability variables, renewable energy penetration rates, and cost-benefit projections to assess the efficiency of PPP-integrated smart grids. Case studies have also been conducted, analyzing contract structures, risk-sharing mechanisms, and operational performance indicators in various PPP projects. Some studies also incorporate multi-criteria decision analysis (MCDA) to evaluate the sustainability of different PPP models.

This section aims to review existing literature on PPP models, financial and policy mechanisms, and smart grid integration, providing insights into optimizing PPP frameworks for a more sustainable energy transition while identifying gaps in the existing research methodologies.

1. Public-Private Partnerships (PPPs) in the Energy Sector

1.1. The General Role of PPPs in Infrastructure Development

PPPs play a fundamental role in infrastructure financing, especially in capital-intensive sectors such as energy. By combining public oversight with private sector expertise, these partnerships facilitate large-scale investments while mitigating financial risks for governments. For instance, Raghutla and Kolati (2023) demonstrate that PPP investments have significantly increased renewable energy production, thereby helping governments address funding gaps and accelerate the deployment of clean technologies. However, their study lacks a thorough analysis of long-term financial sustainability—an essential factor in ensuring the lasting success of PPPs in energy infrastructure.

Casady, Cepparulo, and Giuriato (2024) emphasize that PPPs in energy infrastructure are driven by factors such as budget constraints, technological advancements, and risk-sharing mechanisms. Their research indicates that aligning public policy objectives with private sector incentives is key to fostering long-term sustainability. Yet, their work does not deeply examine the impact of varying contractual models on the performance of PPPs across different energy sub-sectors.

Additional studies, like that by Wang et al. (2022), underscore the role of PPPs in overcoming financing constraints within the energy sector. Their research reveals that energy sector PPPs in Asia have led to significant improvements in efficiency and service delivery, particularly for renewable energy projects. However, Wang et al. (2022) note that geopolitical risks and unstable regulatory frameworks can impede project execution, a challenge that requires further exploration.

Furthermore, the role of multilateral development banks (MDBs) in attracting private sector investments is a key factor in the success of energy PPPs (Fleta-Asín & Muñoz, 2021; Gorodnova, 2023). Research shows that projects backed by MDBs tend to attract more private investors due to risk mitigation mechanisms, financial incentives, and credibility assurance (Batan, 2025). However, MDB-backed projects often involve stringent financial conditions, which may limit flexibility in adapting to local contexts.

1.2. Comparing PPP Models Across Regions

PPP models exhibit notable differences between developed and developing countries, primarily due to variations in regulatory frameworks, financial market maturity, and institutional capacities. In developed nations, PPPs are often structured through long-term concession agreements, where private entities finance, build, and operate infrastructure under stringent regulatory oversight (Sun, Chen, Sun, & Taghizadeh-Hesary, 2020). These models prioritize efficiency, innovation, and service quality but may struggle to adapt to rapidly evolving energy markets.

Conversely, PPPs in developing countries face unique challenges, including limited access to financing, political instability, and regulatory uncertainty (Chauhan & Marisetty, 2019). Governments in these regions often rely on multilateral development banks (MDBs) and international donors to enhance project viability. Fleta-Asín and Muñoz (2021) highlight that MDB involvement is crucial in attracting private investments by reducing financial risks and ensuring institutional stability. However, strict conditions imposed by MDBs can sometimes limit the flexibility needed to tailor projects to local needs.

In addition to traditional models, business structures such as Build-Operate-Transfer (BOT) and Special Purpose Vehicles (SPVs) have emerged as key mechanisms for implementing energy PPPs (Raghutla & Kolati, 2023; Shahbaz et al., 2019). These models allow governments to transfer operational risks to private entities while maintaining ownership over energy infrastructure. BOT projects are particularly useful in developing countries where governments lack the financial capacity to develop large-scale energy facilities independently.

Algarni et al. (2021) further examine PPPs in emerging markets, noting that strong government commitment, legal clarity, and well-defined financial structures are essential for success. Their findings reveal that, despite expanding electricity access through renewable energy projects, regions such as Africa and Latin America continue to face challenges in scaling projects and ensuring equitable energy distribution.

1.3. Key Benefits and Challenges of PPPs in Energy

- **Benefits:**

- **Financial Leverage:** PPPs enable governments to mobilize private funds, significantly reducing the fiscal burden associated with large-scale energy projects (Raghutla & Kolati, 2023).
- **Technological Innovation:** Private sector participation drives advancements in smart grids, energy storage, and renewable integration (Gorodnova, 2023). Yet, ensuring that these innovations are accessible to all stakeholders remains a challenge.
- **Operational Efficiency:** The integration of performance-based contracts and private sector expertise improves service delivery and overall project efficiency (Pinilla-De La Cruz et al., 2022).

- **Risk Diversification:** Well-structured PPPs distribute financial and operational risks between public and private entities, thereby reducing the likelihood of project failures (Wang et al., 2022).
- **Long-Term Energy Security:** Political cooperation and research & development (R&D) investments enhance PPP effectiveness, ensuring sustainability and adaptability to emerging energy challenges (Batan, 2025).

- **Challenges:**
  - **Regulatory Uncertainty:** Unstable policy frameworks can discourage private investment, particularly in developing economies (Othman & Khallaf, 2022).
  - **Risk Allocation Issues:** Ineffective risk-sharing mechanisms may lead to project failures or excessive financial burdens on governments. This challenge is especially pronounced in contexts where enforcement mechanisms are weak (Heldeweg et al., 2015).
  - **Social Acceptance:** Community resistance to large-scale PPP projects often stems from environmental concerns, land-use conflicts, and perceived inequitable benefits (Batan, 2025), highlighting the need for stronger stakeholder engagement strategies.
  - **High Capital Costs:** Many PPP energy projects require substantial upfront investments, which can limit participation from small and medium-sized enterprises (Shahbaz et al., 2019).
  - **Project Complexity:** The extensive negotiations, legal structuring, and long-term commitments required in PPPs can delay implementation. Bureaucratic inefficiencies and limited government capacity further exacerbate these delays (Algarni et al., 2021).

While PPPs offer a promising approach to enhancing energy infrastructure development, their success hinges on well-structured agreements, robust governance frameworks, and balanced risk-sharing strategies. Despite their advantages, critical gaps remain—particularly in optimizing stakeholder engagement, securing long-term financial sustainability, and adapting to rapid technological advancements. Addressing these issues will be essential for maximizing the effectiveness of PPPs in driving the energy transition.

2. PPPs and Their Impact on Energy Transition

2.1. PPP Influence on Energy Transition

Public-Private Partnerships (PPPs) have emerged as a crucial mechanism for accelerating the global energy transition by mobilizing both public and private resources, fostering innovation, and addressing infrastructural gaps in energy systems (Ugwu, Adewusi, & Nwokolo, 2024). By leveraging government incentives and private sector expertise, these partnerships facilitate the deployment of renewable energy projects, contributing to the decarbonization of power grids.

For instance, Wiser et al. (2016) highlight the success of the SunShot Initiative, a PPP between the U.S. Department of Energy (DOE) and private firms, which reduced solar energy costs by 75%. However, while this initiative showcases the cost-reduction potential of PPPs, it does not fully explore the policy adjustments required to sustain these gains long-term. Similarly, O'Connor et al. (2019) examine Google's collaboration with the Renewable Energy Buyers Alliance (REBA), demonstrating how PPPs can facilitate large-scale corporate procurement of renewable energy. Despite these benefits, their study does not sufficiently assess the risks of market volatility affecting long-term project viability.

In emerging economies, PPPs are playing a vital role in expanding energy access. The Azura-Edo Independent Power Plant (IPP) in Nigeria, developed through a PPP with private investors and international financiers, has added 450 MW of capacity to the national grid, improving supply reliability (Herscowitz et al., 2015). However, Ugwu et al. (2024) argue that despite their positive impact, PPPs in developing nations often face challenges such as bureaucratic inefficiencies and regulatory inconsistencies, which can hinder project execution.

2.2. Role of PPPs in Renewable Energy Expansion

The transition to renewable energy requires significant investment, policy support, and financial incentives, all of which can be strengthened through PPPs. Governments provide regulatory frameworks and subsidies, while private sector entities contribute capital investment, technological expertise, and operational efficiency (Taghizadeh-Hesary & Yoshino, 2020).

Gielen et al. (2019) examine PPP-led renewable energy projects in Europe and highlight their role in fostering smart grid integration. Their study suggests that such partnerships improve grid efficiency and facilitate the expansion of decentralized energy systems. However, they do not fully address the scalability of these projects in regions with underdeveloped infrastructure. In contrast, York & Bell (2019) argue that while PPPs have successfully increased renewable energy deployment, they often result in additions rather than transitions—meaning that fossil fuel dependency remains high despite increased clean energy capacity.

A similar trend can be observed in Asia, where Taghizadeh-Hesary & Yoshino (2020) identify PPPs as a key driver of green financing. They highlight that risk-sharing mechanisms reduce financial uncertainties and attract private investment in clean energy. However, their study does not deeply investigate how geopolitical risks and policy instability impact the effectiveness of these financing models.

2.3. Financial and Policy Mechanisms Supporting Energy Transition

Despite their advantages, PPP implementation in the energy sector is often challenged by financial, regulatory, and political factors. Ugwu et al. (2024) note that in developed economies such as the U.S., stable regulatory frameworks and long-term contracts provide certainty for investors. Conversely, in developing nations, weak institutions, inconsistent policies, and corruption create significant barriers to PPP success.

Comparative studies have shown that European nations leverage strong public-private collaboration mechanisms to support energy transition, while some Asian economies rely heavily on multilateral development banks to mitigate financial risks (Taghizadeh-Hesary & Yoshino, 2020). However, York & Bell (2019) caution that merely increasing renewable energy investments through PPPs does not guarantee a reduction in fossil fuel consumption. Their research highlights that in several cases, renewables have been added to the existing energy mix rather than replacing traditional sources, resulting in increased overall energy consumption.

Furthermore, policy-driven approaches such as feed-in tariffs, tax credits, and green bonds have been instrumental in incentivizing private-sector participation in energy PPPs (Gielen et al., 2019). While these mechanisms have proven effective in Europe and North America, their applicability in emerging markets remains a topic of debate due to differing economic conditions and governance structures.

In conclusion, while PPPs are essential for advancing renewable energy and modernizing grid infrastructure, their effectiveness is contingent on well-structured policies, robust financial models, and stable regulatory environments. Future research should focus on optimizing risk-sharing frameworks and ensuring that energy PPPs result in genuine transitions rather than mere capacity expansions.

3. Smart Grid Technology and its Role in Energy Transition

Smart grids represent a fundamental evolution in the energy sector, integrating digital technology with power networks to enhance efficiency, reliability, and sustainability (Butt et al., 2021; Neffati et al., 2021). Unlike traditional power grids, smart grids leverage advanced sensors, automation, and real-time data analytics to optimize electricity generation, distribution, and consumption (Faquir et al., 2021; Giménez de Urtasun et al., 2016). According to Faquir et al. (2021), smart grids enhance efficiency, reliability, and sustainability through two-way digital communication that enables real-time monitoring and control. Unlike conventional grids, which rely on a centralized architecture, smart grids incorporate distributed generation, demand-side management, and automation to improve resilience and operational efficiency.

3.1. Key Features and Advancements

Smart grid technology has significantly advanced in recent years, allowing for improved integration of renewable energy, greater grid resilience, and enhanced efficiency. Neffati et al. (2021) highlight that key smart grid features, such as two-way communication between consumers and utilities, automated demand response, and predictive maintenance, have led to significant reductions in transmission losses and operational costs. However, their study does not fully address the financial and regulatory barriers that may hinder widespread smart grid adoption, such as high initial investment costs, complex permitting processes, and inconsistent policy frameworks across regions. A study by Bensalah (2024) highlights that in many developing economies, financial constraints limit the ability of governments and private firms to invest in large-scale grid modernization, while regulatory uncertainty discourages foreign investment in smart grid infrastructure. Potential strategies to overcome these challenges include increased government subsidies, regulatory reforms to streamline permitting, and stronger collaboration between public and private entities to develop standardized policies.

Giménez de Urtasun et al. (2016) analyze the benefits of smart grid functionalities, particularly the increased reliability and security of energy distribution networks. Their findings demonstrate that investments in smart grids contribute to better outage detection and faster response times. However, they acknowledge that the replicability of smart grid solutions remains a challenge due to differences in national energy policies and market structures.

3.2. Smart Grids as Enablers of Decentralized Energy Production

Decentralized energy production is becoming a critical element in modern energy systems, reducing reliance on centralized power plants and enhancing energy security (Omopariola, 2023; Bensalah, 2024). According to Omopariola (2023), PPPs have played a vital role in fostering decentralized energy systems by supporting distributed generation projects, such as community solar and wind farms. Their study provides strong evidence of how smart grids facilitate the integration of these distributed energy sources, but it lacks a detailed examination of the cybersecurity risks that arise from such a decentralized model.

Neffati et al. (2021) further emphasize that smart grid advancements are essential for achieving a stable and reliable energy supply, particularly in developing countries transitioning to cleaner energy systems. However, their research does not sufficiently explore how differences in digital infrastructure between regions affect the scalability of smart grid technology, such as disparities in broadband access, sensor deployment, and data processing capabilities, which can hinder real-time grid monitoring and automation.

3.3. The Role of Grid Software in PPP Projects

Grid software is increasingly recognized as a vital component in modern energy systems, enabling advanced monitoring, automation, and control functionalities necessary for the effective integration of renewable energy and the optimization of grid operations (Bulu et al., 2023; Bensalah, 2024). Within Public-Private Partnership (PPP) frameworks, grid software plays a central role by bridging the operational goals of public utilities with the technological innovation offered by private firms. These collaborations allow for more dynamic grid management, real-time data analytics, and demand-response coordination, ultimately enhancing system resilience and efficiency (Zhou et al., 2022; Farhadi et al., 2023).

According to Bulu et al. (2023), grid software developed through PPPs has contributed significantly to real-time decision-making and outage management in both developed and emerging markets. Their research highlights the importance of interoperability standards and scalable software architecture to facilitate smooth communication between grid components. However, the study acknowledges that many grid modernization efforts under PPPs face issues such as delayed implementation timelines due to regulatory bottlenecks and unclear public-private roles.

Farhadi et al. (2023) further emphasize that grid software platforms are essential for integrating variable renewable energy sources such as solar and wind. Their analysis of multiple PPP projects in Asia and the Middle East reveals that the most successful implementations included early stakeholder alignment, clear software governance frameworks, and adequate cybersecurity provisions. Yet, the authors note a lack of long-term performance evaluations for such systems, making it difficult to assess the enduring value of these software solutions beyond initial deployment.

In the context of developing economies, Bensalah (2024) outlines how PPPs have facilitated grid software implementation by enabling access to private funding and international expertise. However, the study raises concerns regarding the sustainability of these partnerships when foreign software providers are involved, especially in the absence of local capacity-building initiatives and long-term service agreements. This issue is particularly relevant in countries with limited technical expertise, where software maintenance and customization become ongoing challenges.

Zhou et al. (2022) analyze how grid software within PPPs supports load forecasting, real-time analytics, and energy market integration. Their findings underscore that when grid software is aligned with national digital transformation strategies, PPP projects tend to achieve higher returns and broader stakeholder engagement. However, they also caution that weak legal frameworks and data ownership disputes can impede the scalability of such digital solutions, especially in multi-vendor environments.

Despite these limitations, the strategic use of grid software in PPP projects has proven essential for advancing the energy transition. Integrated platforms enhance visibility over grid operations, improve fault detection, and allow for more responsive infrastructure planning. As digitalization becomes central to energy policy, the continued refinement of PPP models including contractual clarity, shared risk frameworks, and interoperability standards will be key to unlocking the full potential of grid software in supporting cleaner, smarter energy systems (Farhadi et al., 2023; Zhou et al., 2022).

3.4. Digital Solutions for Energy Management

Advanced grid software solutions have evolved significantly over the past two decades, enhancing energy efficiency by optimizing electricity distribution, forecasting demand patterns, and integrating renewable energy sources into the grid (Neffati et al., 2021; Rumiantsev et al., 2023). Initially, grid management relied on rudimentary SCADA systems, but the introduction of AI-driven analytics, blockchain-based energy trading, and real-time automation has revolutionized grid operations (Giménez de Urtasun et al., 2016). These advancements have not only improved grid stability but also enabled better predictive maintenance and faster response to demand fluctuations. Neffati et al. (2021) highlight the use of AI-driven predictive analytics and blockchain-based energy trading platforms as key innovations that improve grid stability and responsiveness. However, their study does not account for the high initial costs and technological requirements that may limit adoption in less developed markets.

Rumiantsev et al. (2023) provide case studies from Europe and North America, showcasing successful implementations of grid software in modernizing energy infrastructure. While these examples illustrate best practices, they do not sufficiently address the policy and regulatory challenges associated with deploying grid software in regions with outdated or fragmented regulatory frameworks. For example, in developing regions such as Sub-Saharan Africa, inconsistent policies and limited regulatory oversight have hindered the deployment of smart grid solutions, delaying modernization efforts (Neffati et al., 2021). However, recent policy initiatives, such as the African Development Bank's Desert to Power initiative and national electrification programs in Kenya and Nigeria, aim to address these issues by streamlining regulations, enhancing investment incentives, and fostering cross-border energy collaboration (Bensalah, 2024). Similarly, in parts of Eastern Europe, outdated legal frameworks and slow bureaucratic processes have created barriers to the seamless integration of advanced grid software (Rumiantsev et al., 2023). Implementing standardized regulatory policies, fostering international collaboration, and encouraging public-private partnerships to streamline compliance processes could help overcome these challenges.

3.5. Cybersecurity and Interoperability Concerns

As smart grids become more interconnected, cybersecurity risks and interoperability issues pose significant challenges (Faquir et al., 2021; Maglaras et al., 2021). Faquir et al. (2021) warn that cyberattacks on critical energy infrastructure could lead to widespread disruptions, posing economic and security threats. Their study underscores the importance of robust cybersecurity frameworks, yet it lacks specific recommendations for how PPPs can effectively mitigate these risks.

Neffati et al. (2021) emphasize that ensuring interoperability between different grid systems is essential for the seamless integration of smart grid solutions. However, challenges such as incompatible communication protocols, differences in grid management software, and lack of standardized cybersecurity measures have created barriers to full interoperability. For instance, in Europe, variations in regulatory requirements between countries have slowed down cross-border energy trading and grid synchronization efforts (Rumiantsev et al., 2023). Addressing these issues requires harmonized policies and greater collaboration between international standardization bodies. However, regulatory fragmentation and a lack of standardization continue to hinder progress in this area. Addressing these concerns will require greater international cooperation and coordinated policy efforts to establish global interoperability standards. Organizations such as the International Electrotechnical Commission (IEC), the

International Energy Agency (IEA), and the Smart Grid Interoperability Panel (SGIP) are actively working to develop standardized frameworks for seamless integration of smart grid technologies. For instance, the IEC has developed the IEC 61850 standard for substation automation, which facilitates interoperability between different grid components. The IEA has launched the Digital Demand-Driven Electricity Networks Initiative, which aims to improve grid digitalization and data-sharing frameworks. Additionally, SGIP has focused on the creation of a Common Information Model (CIM) to standardize data exchange between utilities and grid operators (Neffati et al., 2021).

The implementation of smart grid and grid software technologies is pivotal in the transition towards a more efficient and resilient energy system. By integrating advanced communication technologies, renewable energy sources, and AI-driven analytics, smart grids enhance energy efficiency and reliability. However, challenges such as cybersecurity risks and regulatory barriers must be addressed to fully realize their potential. Public-private partnerships (PPPs) play a vital role in accelerating smart grid adoption by facilitating investments, fostering innovation, and ensuring sustainable energy solutions. For instance, the U.S. Department of Energy's Smart Grid Investment Grant (SGIG) program, a PPP initiative, successfully modernized grid infrastructure by integrating advanced metering systems and demand response technologies, improving grid efficiency and reliability (Omopariola, 2023). Similarly, in Europe, the PROMOTioN project focused on offshore wind energy integration through collaborative investments between governments and private stakeholders, showcasing the effectiveness of PPPs in advancing smart grid solutions (Rumiantsev et al., 2023). The project resulted in the development of meshed offshore grids, improved transmission reliability, and reduced overall costs of wind energy integration. Additionally, the project contributed to regulatory frameworks that facilitate cross-border electricity trade and enhance grid stability across European nations.

II. Conceptual Framework

In this section, we present the epistemological approach adopted, define the key concepts mobilized in our research, and introduce the conceptual model, which revolves around Public-Private Partnerships (PPPs), energy transition, and grid software.

1. Research Objective:

The primary objective of this research is to assess the impact of Public-Private Partnerships (PPPs) on energy transition through the implementation of grid software. This objective is broken down into the following sub-objectives:

- Evaluate how PPPs contribute to the development and deployment of grid software.
- Analyze the role of grid software in enhancing energy efficiency and renewable integration.
- Measure the impact of PPP-driven grid software solutions on energy transition goals.
- Identify key challenges and opportunities in implementing PPP-based grid software solutions.

2. Key Concepts and Theoretical Model

2.1. Public-Private Partnerships (PPPs)

Public-Private Partnerships (PPPs) are defined as collaborative agreements between public and private sector entities aimed at financing, developing, and operating infrastructure projects, including those in the energy sector (Casady et al., 2024). The World Bank (2021) describes PPPs as long-term contracts between a government and a private party, where the private party assumes significant risk and management responsibility in delivering public services or infrastructure. These partnerships leverage private sector investment and expertise while ensuring public oversight and policy alignment (Fleta-Asín & Muñoz, 2021). Furthermore, Grimsey and Lewis (2004) highlight that successful PPPs depend on clearly defined risk-sharing mechanisms, financial sustainability, and institutional commitment.

2.2. Grid Software Solutions

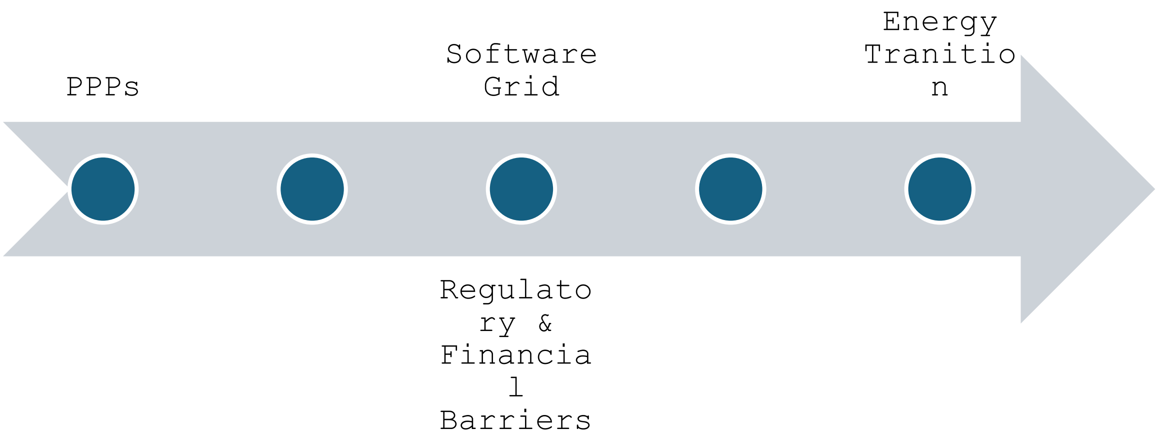
Grid software refers to digital solutions that enhance energy distribution, facilitate renewable energy integration, and optimize grid operations through automation and real-time data analytics (Neffati et al., 2021). The International Energy Agency (IEA, 2022) defines grid software as a suite of digital tools used for electricity grid monitoring, forecasting, and optimization to improve efficiency and reliability. According to Rumiantsev et al. (2023), grid software includes advanced sensors, AI-driven forecasting, and blockchain-based energy trading platforms that improve grid stability and energy efficiency. Additionally, Faquir et al.

(2021) emphasize that smart grid software is essential for demand-side management, reducing energy losses, and enhancing grid resilience against fluctuations in supply and demand.

2.3. Energy Transition Outcomes:

Energy transition is defined as the shift from fossil fuel-based energy systems to cleaner, more sustainable energy alternatives, with a focus on increasing renewable energy adoption and improving energy efficiency (Taghizadeh-Hesary & Yoshino, 2020). The International Renewable Energy Agency (IRENA, 2023) defines energy transition as "a pathway toward the transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century." York & Bell (2019) highlight that a successful energy transition involves structural changes in energy production, distribution, and consumption patterns, facilitated by technological advancements such as smart grids and digital energy management systems. Additionally, Sovacool (2016) argues that energy transitions are driven by policy support, technological innovation, and changing socio-economic conditions that shape the adoption of renewable energy solutions.

Figure 1: Theoretical Model of PPPs, Grid Software, and Energy Transition



Source: Developed through personal efforts

3. Research Hypotheses

Based on the literature review and conceptual framework, the following hypotheses have been formulated:

3.1. The Impact of Public-Private Partnerships on Grid Software Development

Several studies emphasize the role of PPPs in fostering digital grid solutions. Raghutla and Kolati (2023) argue that PPP investments accelerate smart grid deployment by mobilizing financial resources and reducing risks for private investors. Similarly, Casady et al. (2024) highlight that well-structured PPP agreements contribute to grid digitalization by ensuring long-term operational efficiency and reducing technological gaps. Moreover, Sun et al. (2020) demonstrate that financial incentives within PPP frameworks enhance private sector participation in smart grid projects. Based on these findings, we propose:

H1: Public-Private Partnerships have a positive impact on grid software development.

3.2. The Role of Grid Software in Energy Transition

Smart grid software enhances the efficiency of energy transition initiatives by optimizing power distribution and integrating renewable energy sources. According to Giménez de Urtasun et al. (2016), advanced grid management software significantly reduces transmission losses and improves real-time energy monitoring. Additionally, Neffati et al. (2021) underscore the role of digital grid solutions in supporting decentralized energy production and improving grid resilience. Furthermore, Rumiantsev et al. (2023) note that AI-driven forecasting systems enhance energy demand prediction and supply balance. Therefore, we hypothesize:

H2: Grid software solutions improve the efficiency of energy transition initiatives.

3.3. The Contribution of Public-Private Partnerships to Energy Transition Through Grid Software

PPPs facilitate the deployment of grid software, leading to a more efficient and sustainable energy transition. Othman and Khallaf (2022) note that PPPs help governments leverage private sector expertise in grid modernization and smart grid integration. Similarly, Wang et al. (2022) emphasize that PPP-driven projects in Asia have significantly improved renewable energy penetration. Moreover, Taghizadeh-Hesary and Yoshino (2020) argue that well-structured PPP financial mechanisms encourage green investments. Thus, we hypothesize:

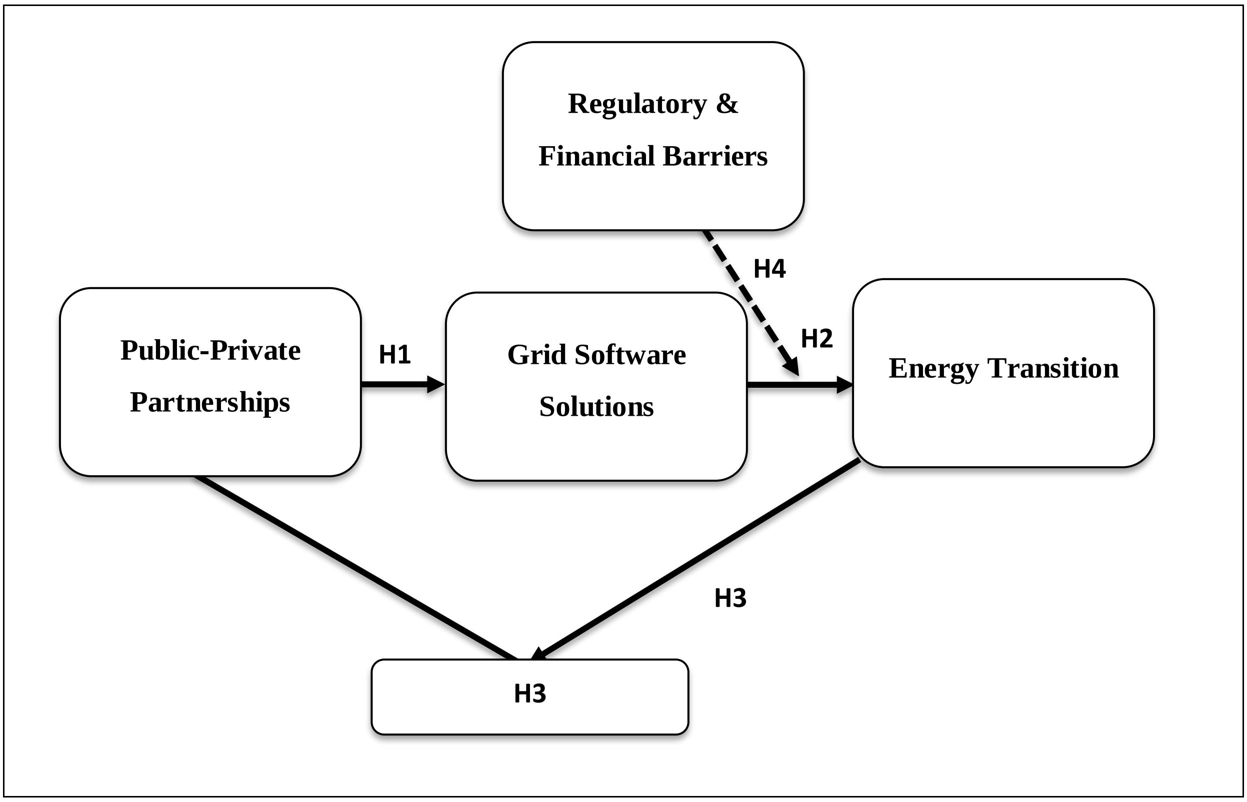
H3: Public-Private Partnerships positively influence energy transition through grid software.

3.4. The Moderating Role of Regulatory and Financial Challenges:

Despite their advantages, PPP projects often face regulatory and financial barriers that can limit their effectiveness. Heldeweg et al. (2015) argue that inconsistent regulatory frameworks can delay smart grid deployment and reduce investor confidence. Shahbaz et al. (2019) further highlight that high capital costs and limited access to financing may hinder the scalability of PPP-driven grid solutions. Additionally, Batan (2025) notes that social acceptance and environmental concerns can pose additional barriers to large-scale PPP initiatives. Based on these challenges, we propose:

H4: Regulatory and financial challenges moderate the effectiveness of PPP-driven grid software solutions.

Figure 2: Schematic Representation of Hypotheses and Relationships Between Variables



Source: Developed through personal efforts

4. Summary of Hypotheses

Table 1: Summary table of assumptions

Variable Type	Concept	Hypothesis	Sources
Independent	Public-Private Partnerships	H1: PPPs have a positive impact on grid software development.	Raghutla & Kolati (2023); Casady et al. (2024); Sun et al. (2020)
Independent	Grid Software Solutions	H2: Grid software solutions improve energy transition efficiency.	Giménez de Urtasun et al. (2016); Neffati et al. (2021); Rumiantsev et al. (2023)
Dependent	Energy Transition	H3: PPPs positively influence energy transition through grid software.	Othman & Khallaf (2022); Wang et al. (2022); Taghizadeh-Hesary & Yoshino (2020)
Moderator	Regulatory & Financial Barriers	H4: Regulatory and financial challenges moderate the effectiveness of PPP-driven grid software solutions.	Heldeweg et al. (2015); Shahbaz et al. (2019); Batan (2025)

Source: Developed through personal efforts

CHAPTER II: METHODOLOGICAL FRAMEWORK AND CONTEXT OF THE RESEARCH

In this chapter, we will discuss the methodological approach chosen to conduct our study in the first part and the research context in the second part. Where we will address the research methods and data collection instruments selected to achieve our objectives and answer the research question.

I. METHODOLOGICAL FRAMEWORK

1. Research Design

This study adopts a predominantly quantitative approach, enriched with supporting qualitative elements where necessary. The quantitative dimension relies on statistical analyses, structured surveys, and energy performance data to examine the role of public-private partnerships (PPPs) in Algeria's energy transition. The inclusion of qualitative data serves only to contextualize and reinforce quantitative findings, rather than to drive the analysis.

A pragmatic epistemological stance is employed to integrate empirical evidence with expert insights, ensuring a comprehensive understanding of the impact of Siemens' Grid Software in collaboration with Sonelgaz and other public entities. Pragmatism allows for a flexible research approach that acknowledges both theoretical perspectives and real-world complexities in Algeria's energy transition.

By prioritizing quantitative methods, the study captures measurable indicators of collaboration between Siemens and public entities like Sonelgaz, while ensuring that the supporting qualitative elements provide relevant contextualization without overshadowing the quantitative rigor. To enhance the robustness of findings, data triangulation is employed, validating insights through multiple sources such as structured surveys, statistical reports, observations, and documentary analysis.

2. Data Collection Methods

2.1. Data Collection Approach and Instruments:

To achieve the objectives of this study, all was conducted across multiple organizations directly involved in Algeria's energy transition initiatives, including Siemens, Sonelgaz, the Ministry of Energy, and ALNAFT.

The following methods were employed:

- Structured questionnaires administered to representatives from Siemens, Sonelgaz, the Ministry of Energy, and ALNAFT involved in energy transition projects.
- Analysis of case studies and reports on past and ongoing collaborations between Siemens and Sonelgaz for the implementation of Grid Software.

- Documentary analysis of internal Siemens reports, project documentation, and strategic planning materials.

These instruments were selected for their ability to yield measurable, context-specific data. The structured questionnaire format ensured consistency across participants while allowing for the collection of quantifiable responses. Internal reports and documents were evaluated for credibility, reliability, and relevance to the research focus.

- Supporting qualitative data were also collected, including:

o Extracts from internal Siemens performance reports on energy efficiency and CO_2 emissions reductions linked to grid modernization.

o Descriptive analysis of project impact assessments to contextualize quantitative findings.

Preliminary testing of questionnaire items and case study selection criteria was conducted to refine the tools and eliminate redundancy. Application-oriented items were incorporated into the questionnaire, informed by preliminary assessments, to systematically investigate the practical implementation of Grid Software.

2.2. Questionnaire Design and Structure

To examine the research objectives, an online structured questionnaire was designed to assess the impact of Public-Private Partnerships (PPPs) on Algeria's energy transition through grid software deployment. This instrument was designed to gather insights from professionals affiliated with key organizations such as Siemens, Sonelgaz, the Ministry of Energy, ALNAFT, and other relevant entities.

The questionnaire comprises five main sections, each targeting specific aspects of the research objectives and informed by the literature review where the items have been drawn directly (see citations) to ensure construct validity and alignment with our analysis model.

It was developed in both French and English to ensure clear understanding among respondents, as Siemens is an international company operating in Algeria, where French is commonly used in professional environments.

2.3. Measurement Instrument

A Questionnaire was used as a tool for collecting the required information. In the following section, we present the structure of the questionnaire as well as the measurement scales used for the variables included in the theoretical model.

2.3.1. Questionnaire Structure

The questionnaire is organized into the following sections:

- **Introduction:** A brief explanation of the survey's academic purpose, its confidentiality, and its importance for improving PPP strategies in clean energy infrastructure. The introduction emphasizes the participant's anonymity and time efficiency (less than 5 minutes).
- **Eligibility Filter:** One binary question screens participants to ensure they have experience in energy transition or smart-grid projects. Those answering "No" are disqualified to maintain data relevance.
- **Survey Constructs Sections:** This section constitutes the core of the questionnaire, directly addressing the research objectives by examining the dynamics of public-private partnerships (PPPs) and smart grid software in Algeria's energy transition. The questions are organized into four thematic constructs, with items adapted from peer-reviewed literature to ensure content validity. Each construct is measured using appropriate Likert-type scales (e.g., from Strongly Disagree to Strongly Agree, or from Very Effective to Not at All), depending on the variable assessed.

The constructs include:

  - **PPP Effectiveness:** Measures the perceived contribution of PPPs particularly the Siemens–Sonelgaz collaboration in accelerating deployment, reducing implementation risks, and enhancing long-term operational efficiency.
  - **Software Impact:** Assesses the technical and environmental performance of grid software, including system stability, emissions reduction, and integration of renewable sources.
  - **Contribution to the Energy Transition:** Evaluates the extent to which PPP-driven software initiatives support national energy transition goals through infrastructure resilience and accelerated project timelines.
  - **Regulatory and Financial Obstacles:** Investigates perceived barriers such as legislative complexity, investment costs, and the potential of financial incentives to mitigate risk.

- **Respondent Information:** Demographic and professional profile items are included for segmentation and deeper analysis of contextual variables.
- **Closing Statement:** A simple appreciation message to thank respondents and confirm the end of the questionnaire.

2.3.2. Measurement Scales

The questionnaire employs a 5-point Likert scale for most items, allowing respondents to express degrees of agreement or effectiveness. This scale ranges from "Strongly Disagree" to "Strongly Agree" or from "Not at all" to "Very Effectively," depending on the question context. Such scaling facilitates nuanced data collection and analysis.

Table 2: Interpretation of 5-Point Likert Scale Measurements

Likert Scale	**Interval**	**Difference**	**Description**
1	1.00–1.79	0.79	Strongly disagree
2	1.80–2.59	0.79	Disagree
3	2.60–3.39	0.79	Neutral
4	3.40–4.19	0.79	Agree
5	4.20–5.00	0.80	Strongly agree

Source: Pimentel, 2019

Table 3: Measurement Scales Used in the Questionnaire

Variable	Items	Scale	References
PPP Effectiveness	1. The Siemens–Sonelgaz partnership accelerates the deployment of smart grid software by providing funding and expertise. 2. The contractual arrangements in PPPs help reduce risks during the implementation of grid software projects. 3. Collaboration through PPPs ensures long-term operational efficiency of grid software.	5-point Likert scale (Strongly Agree – Strongly Disagree)	Raghutla & Kolati (2023), Casady et al. (2024), Sun et al. (2020)
Software Impact	1. Advanced grid software helps stabilize voltage and frequency when renewable energy output fluctuates. 2. Grid software deployment has measurably reduced CO_2 emissions in our projects. 3. Real-time analytics from grid software supports the integration of more renewable energy into the electricity mix.	Mixed scales: Efficiency (Very Effective – Not at all), Impact (Significant – Negative), Agreement (SA – SD)	Giménez de Urtasun et al. (2016), Neffati et al. (2021), Rumiantsev et al. (2023)
Contribution to the Transition	1. Through PPPs, Siemens has integrated grid software to help meet Algeria's energy transition goals. 2. The Siemens–Sonelgaz partnership has strengthened infrastructure resilience through grid software solutions. 3. PPP-driven software deployment accelerated project timelines toward decarbonization.	5-point Likert scale (Strongly Agree – Strongly Disagree)	Othman & Khallaf (2022), Wang et al. (2022), Taghizadeh-Hesary & Yoshino (2020)
Obstacles	1. Regulatory complexity significantly delays grid software implementation under PPPs. 2. High investment costs limit the success of grid software projects under PPPs. 3. Financial incentives within PPPs sufficiently mitigate investment risks for grid software.	Agreement (SA–SD), Binary evaluation (Yes / No / Partially)	Heldeweg et al. (2015), Shahbaz et al. (2019), Batan (2025)

Source: Developed through personal efforts

3. Sampling

3.1. Study Population

The study population consists of professionals from Siemens, Sonelgaz, the Ministry of Energy, and ALNAFT who are directly involved in energy transition projects, including technical experts, project managers, policy advisors, and strategic decision-makers. By extending participation beyond Siemens to key external stakeholders, the research captures a broader, quantifiable perspective on the implementation and impact of Grid Software in Algeria's energy transition. This diverse sampling ensures a more comprehensive and statistically significant dataset for analysis.

3.2. Sampling Method

A purposive sampling method was employed across Siemens, Sonelgaz, the Ministry of Energy, and ALNAFT to ensure that only relevant and knowledgeable participants contribute to the study. The selection criteria focused on professionals engaged in public-private partnerships and the deployment of grid software technologies in Algeria. Participants were identified through organizational directories, official communications, and professional referrals.

This targeted approach was chosen to obtain a comprehensive and expert-driven dataset capable of supporting robust quantitative analysis of the study’s subject matter.

3.3. Sample Size

To ensure statistically meaningful results, the study targeted approximately 30–70 professionals across Siemens, Sonelgaz, the Ministry of Energy, and ALNAFT who are involved in energy transition projects. This sample size aligns with quantitative research best practices, allowing for robust data analysis while maintaining feasibility within the study’s scope. Responses that did not meet predefined relevance or completeness criteria—based on alignment with the study's focus areas and the quality of questionnaire completion—were excluded from the final analysis.

4. Data Analysis Methods

Given the quantitative nature of this study, the following evaluation and analysis strategies were used:

- Descriptive statistical analysis of questionnaire responses to summarize participant characteristics, perceptions, and experiences related to energy transition projects.
- Quantitative analysis of Siemens' internal assessments of the effectiveness of Grid Software in enhancing energy transition efforts.

• Identification of policy and regulatory challenges through aggregated questionnaire data.

• Exploration of technological adoption success factors based on participants' survey responses across Siemens, Sonelgaz, the Ministry of Energy, and ALNAFT.

• Overview of key performance metrics (e.g., grid efficiency, energy consumption patterns) using internal reports combined with questionnaire findings.

• Cross-verification of findings through Siemens' internal expert review processes to align statistical results with industry realities.

These analytical procedures ensured that numerical data were interpreted systematically and rigorously.

To analyze the questionnaire data, a statistical analysis approach was employed, following these steps:

✓ Data entry and cleaning using Excel and SPSS to ensure accuracy and completeness;

✓ Descriptive statistics (means, frequencies, percentages) to summarize key variables;

✓ Cross-tabulations to explore relationships between variables such as sector affiliation and perceptions of PPP effectiveness;

✓ Correlation analysis to identify associations between key factors like technological adoption success and perceived grid efficiency improvements;

✓ Interpretation of findings in relation to the study's research questions and hypotheses.

The quantitative data analysis provided a structured, objective understanding of how PPPs influence energy transition through grid software technologies in the Algerian context.

5. Ethical Considerations

All ethical principles of quantitative research were rigorously followed. Participants were informed of the study's purpose, the voluntary nature of their participation, and their right to withdraw at any time without consequence. Informed consent was obtained electronically or in writing prior to completing the questionnaire. Anonymity was ensured by not collecting personally identifiable information, and all responses were treated with strict confidentiality.

All data (questionnaire responses, internal reports) were stored in password-protected folders accessible only to the researcher. Data files, whether in Excel or SPSS format, were encrypted and securely stored. No data were shared with third parties. Given that the study involves sensitive organizations (Siemens Algeria, Sonelgaz, the Ministry of Energy, and ALNAFT), special attention was given to preserving the confidentiality of organizational insights and avoiding the disclosure of sensitive operational details.

II. RESEARCH CONTEXT

1. Brief Overview of the Sector

1.1. The Energy Sector and the Energy Transition in Algeria

The energy sector in Algeria is a fundamental pillar of the national economy, deeply embedded in the country's industrial development and public policy. As one of Africa's leading producers of oil and natural gas, Algeria has long relied on hydrocarbon exports to sustain state revenues and economic growth. However, in recent years, this model has faced mounting pressure. Domestic energy consumption is rising rapidly, global oil prices remain volatile, and international climate commitments are pushing for a transition away from fossil fuels. Together, these factors have compelled Algerian authorities to rethink the country's energy future.

In response, the government has launched an ambitious energy transition policy aimed at diversifying the national energy mix and promoting low-carbon development. Central to this strategy is the Renewable Energy and Energy Efficiency Development Program, which sets a target of 22 GW of installed renewable energy capacity by 2030, with 13.6 GW dedicated to the national market. this includes energy sources such as photovoltaic solar, wind, biomass, geothermal, and cogeneration but primarily through solar and wind power. The program is complemented by policy reforms to encourage investment, develop public-private partnerships (PPPs), and modernize the electricity grid.

Yet, despite these policy signals, progress has been modest. The deployment of renewable energy remains constrained by a combination of outdated infrastructure, centralized governance, insufficient private sector involvement, and a lack of digitalization across the electricity value chain.

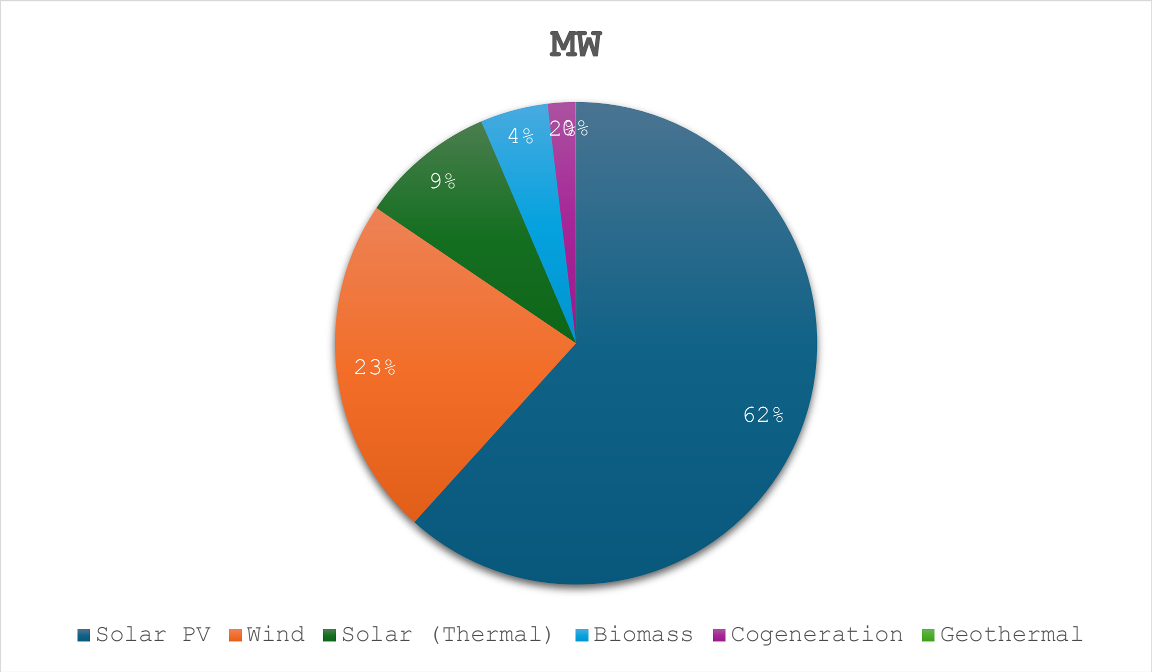
To better understand Algeria's current position and future trajectory, the Friedrich Ebert Stiftung (FES) MENA Phase Model offers a helpful analytical framework. This model outlines four progressive phases of sustainable energy transition:

- **Phase 1**: Renewable Energy Takeoff (Décollage des énergies renouvelables),
- **Phase 2**: Integration into the System,
- **Phase 3**: Sector-Coupling and Power-to-X Transformation,
- **Phase 4**: Toward a 100% Renewable Energy System.

According to this model, Algeria is situated between Phases 1 and 2, having initiated renewable energy deployment but still facing significant challenges in terms of grid integration, decentralization, and market reform. Moving beyond this transitional stage requires not only political commitment but also a profound technological shift particularly in the digital infrastructure that underpins modern energy systems.

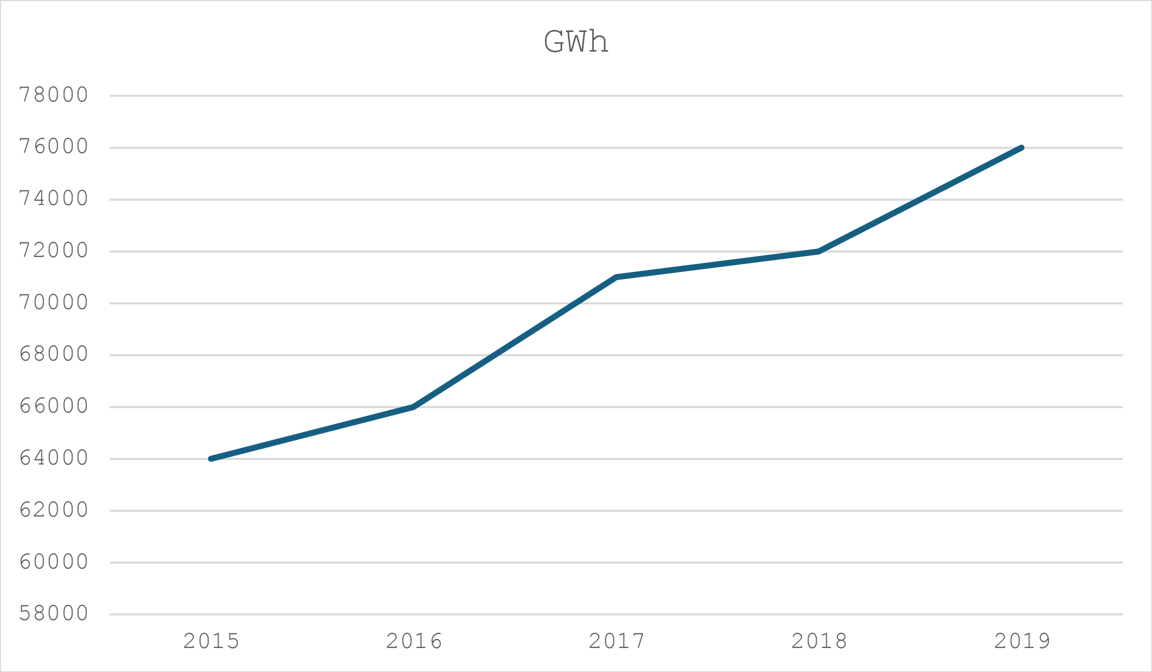
This is where Siemens' Grid Software solutions emerge as a critical enabler. Through advanced digital tools such as real-time monitoring, automated grid control, and predictive analytics. Siemens supports Algeria's efforts to manage the complexity of renewable energy integration, stabilize grid operations, and accelerate the transition toward a smarter, more resilient electricity network.

Figure 3: 2030 Targeted Renewable Energy mix (MW)



Source: Algerian Ministry of Energy

Figure 4: Algeria’s Electric Generation Evolution, 2015-19 (GWh)



Source: BNEF

2. Host Organization

In this section, we present the host structure and institutional framework relevant to this research: **Siemens** as the primary technology provider and its collaboration with **Sonelgaz**, the national electricity operator in Algeria.

3. Definition and Positioning of Siemens in Algeria

3.1. Historical Background

Siemens AG, a global leader in technology and engineering, has a rich history spanning over 175 years. Here's an overview of its evolution:

Figure 5: Logo Siemens AG

Source: Siemens official website – www.siemens.com

- **Founding and Early Innovations (1847–1865):**

Siemens was established on October 1, 1847, in Berlin by Werner von Siemens and Johann Georg Halske. Their initial innovation was the pointer telegraph, which used a needle to indicate letters, simplifying communication compared to Morse code. The company's first major project was constructing a telegraph line between Berlin and Frankfurt in 1848, marking its entry into large-scale infrastructure projects.

- **Expansion and Global Reach (1866–1914):**

In 1866, Siemens discovered the dynamo-electric principle, leading to the development of efficient electrical generators. This breakthrough propelled the company into the electrical engineering sector. By the late 19th century, Siemens had expanded internationally, establishing operations in countries like the UK, Russia, and Japan, and diversifying into products like electric trains and medical equipment.

- **20th Century Developments and Challenges:**

Throughout the 20th century, Siemens continued to grow, merging with other companies to form Siemens AG in 1966. The company faced challenges during both World Wars but managed to rebuild and expand its operations post-conflict. In the latter half of the century, Siemens diversified into areas like computing, telecommunications, and automation.

- **Modern Era and Digital Transformation:**

In recent decades, Siemens has focused on digitalization and sustainability. The company has restructured to concentrate on core areas such as automation, smart infrastructure, mobility, and healthcare. Notably, in 2020, Siemens spun off its energy division into a separate entity, Siemens Energy, to better address the evolving energy market.

Today, Siemens AG is headquartered in both Berlin and Munich, operating in over 190 countries with a workforce of approximately 327,000 employees. The company's enduring commitment to innovation and adaptability has solidified its position as a leader in various technological domains.

- **In Algeria:**

Siemens’ involvement in Algeria dates back to 1857, when Werner von Siemens contributed to the installation of the first submarine telegraph cable linking Cagliari (Italy) and Annaba (Algeria). This initiative marked one of the earliest technological connections between Europe and North Africa.

Following Algeria’s independence, Siemens became the first multinational company to obtain a commercial registration in Algeria, on August 20, 1962, establishing itself as a pioneer in the country’s industrial and technological development.

3.2. Legal and Organizational Framework of Siemens Algeria

Siemens Algeria operates as a subsidiary of Siemens AG, adhering to both international corporate governance standards and Algerian commercial laws. The company is registered with the Algerian Ministry of Industry and Energy, holding the following identifiers:

- **Trade Register Number (RC):** 23B1282283
- **Legal Form:** Limited Liability Company (Société à Responsabilité Limitée - SARL)
- **Capital:** 5,000,000 DZD
- **Registration Date:** August 16, 2023
- **Headquarters Address:** Lot n°10, Subdivision Moutchatchou, El Kadous, Groupe, 7th Floor, Hydra, Algiers, 16035

Organizational Structure

Aligned with Siemens AG's global organizational model, Siemens Algeria is structured into the following major divisions:

- **Smart Infrastructure:** Focuses on intelligent and sustainable infrastructure solutions, integrating energy systems, buildings, and transportation
- **Digital Industries:** Caters to the digital transformation of industrial customers, offering automation, digitalization, and software solutions.
- **Mobility:** Provides comprehensive mobility solutions, including rail systems and related services.
- **Healthcare (Siemens Healthineers):** Delivers medical technology and digital health services.
- **Grid Software:** Specializes in advanced software solutions for energy grid management, playing a pivotal role in Algeria's energy transition.

Geographical Presence

While the central headquarters is located in Algiers, Siemens Algeria has extended its operational footprint to other key regions:

- **Oran:** Serving the western region, focusing on energy projects and industrial collaborations.
- **Constantine:** Catering to the eastern region, supporting infrastructure and digital industry initiatives.

These branches enable Siemens Algeria to effectively address regional demands and contribute to national development goals.

3.3. Legislative Framework Governing Siemens' Operations in Algeria

Siemens' activities in Algeria are governed by a comprehensive legal framework that aligns with the country's energy sector regulations and international corporate standards.

✓ **Law No. 02-01 of February 5, 2002**

This foundational law restructured Algeria's electricity and gas sectors, introducing principles of transparency and competitiveness. It established the Electricity and Gas Regulation Commission (CREG) as an independent authority responsible for overseeing the market's organization and ensuring compliance with regulations.

✓ **Law No. 04-09 of August 4, 2004**

Aimed at promoting renewable energy within sustainable development, this law supports Algeria's energy transition by encouraging the integration of renewable energy sources into the national grid.

✓ **Law No. 19-13 of December 11, 2019**

This law governs hydrocarbon activities, outlining the legal framework for exploration, production, and commercialization of hydrocarbons, ensuring environmental protection and sustainable resource management.

✓ **Executive Decree No. 04-92 of March 25, 2004**

This decree introduced a feed-in tariff system to diversify electricity production costs, incentivizing the development of renewable energy projects by guaranteeing purchase prices for electricity generated from renewable sources.

✓ **Executive Decree No. 21-319 of August 14, 2021**

This decree defines the operating authorization regime for hydrocarbon installations and facilities, including procedures for approving risk studies and ensuring environmental compliance.

✓ **Distribution Concession Regime (Decree No. 08-114 of April 9, 2008)**

Implemented by CREG, this regime introduced distribution concessions for electricity and gas transport, allowing entities like Sonelgaz to hold concessions for distribution plots, thereby fostering a more competitive market environment.

✓ **German-Algerian Energy Partnership (2015–2026)**

Established through a declaration of intent between Germany and Algeria, this partnership aims to support Algeria in expanding renewable energy use and developing green hydrogen, contributing to the global energy transition.

3.4. Missions of Siemens Algeria:

Siemens Algeria, a subsidiary of the global Siemens AG, has been a key player in Algeria's industrial and technological development since its establishment in 1962. The company's primary missions encompass the following sectors:

- **Energy Sector**: Siemens Algeria plays a pivotal role in modernizing and securing Algeria's energy landscape, addressing both growing domestic energy demands and the national agenda for sustainable development. Its involvement spans the full energy value chain—from power generation to transmission and distribution systems.

In the field of power generation, Siemens Algeria has supplied cutting-edge gas turbines, steam turbines, and combined-cycle technologies that significantly boost the efficiency of thermal power plants. Two flagship projects include the Ras Djinet and Berrouaghia thermal power stations, where Siemens provided essential components and engineering expertise. These plants have notably contributed to increasing Algeria's installed power capacity, improving national energy security, and supporting economic growth.

In terms of transmission and distribution, Siemens Algeria deploys smart grid solutions, advanced substations, and high-voltage technologies that enhance the resilience and flexibility of Algeria’s national grid. The company’s innovations in this area are crucial for minimizing transmission losses, integrating renewable energy sources, and ensuring a more stable electricity supply to both urban and rural regions.

Moreover, Siemens Algeria is increasingly active in grid modernization initiatives, focusing on digitalization and automation. Through its Grid Software solutions, Siemens facilitates real-time monitoring, predictive maintenance, and optimal load management, all of which are critical for ensuring the efficiency and sustainability of the Algerian power network.

Additionally, Siemens provides training and capacity-building programs for local engineers and technicians. By transferring technical know-how and offering specialized workshops, Siemens supports the long-term development of Algeria’s energy workforce and reinforces national self-sufficiency in managing advanced energy infrastructures.

Through these multi-faceted contributions, Siemens Algeria solidifies its mission to not only supply technology but also act as a strategic partner in the country's broader energy transition and industrial modernization efforts.

- **Industrial Automation and Digitalization**: The company provides comprehensive solutions for industrial automation, facilitating the digital transformation of Algerian industries. Through its Digital Industries division, Siemens offers cutting-edge technologies that improve operational efficiency and productivity across various sectors.

- **Healthcare Services**: Siemens Healthineers, the healthcare division of Siemens, delivers state-of-the-art medical imaging and diagnostic equipment to Algerian healthcare facilities. This includes the installation of over a hundred imaging systems, contributing to the enhancement of medical services in the country.
- **Mobility and Transportation**: Siemens has played a pivotal role in developing Algeria's transportation infrastructure. The company has been instrumental in projects like the Algiers metro and has provided signaling and telecommunications solutions for various railway lines, improving the efficiency and safety of public transportation.
- **Smart Infrastructure**: Through its Smart Infrastructure division, Siemens offers integrated solutions for building technologies, including energy-efficient systems and automation for commercial and residential buildings. This contributes to the development of sustainable urban environments in Algeria.

3.5. Organizational Structure of Siemens Algeria

Siemens Algeria's organizational framework is designed to effectively manage its diverse operations across the country. The structure is as follows:

- **Central Headquarters**: Located in Algiers, the central headquarters houses the main administrative and executive functions, overseeing the company's nationwide activities.
- **Regional Offices**: To ensure efficient service delivery and client engagement, Siemens Algeria has established regional offices in key cities, including Oran and Constantine. These offices coordinate local projects and maintain close relationships with regional stakeholders.
- **Specialized Divisions**: The company is organized into specialized divisions corresponding to its main areas of operation:
    - *Energy*: Focuses on power generation and distribution solutions.
    - *Digital Industries*: Handles industrial automation and digitalization services.
    - *Healthcare*: Manages the provision of medical technologies and services.
    - *Mobility*: Oversees transportation infrastructure projects.
    - *Smart Infrastructure*: Deals with building technologies and energy systems.
- **Training and Development Centers**: Siemens Algeria places a strong emphasis on capacity building and knowledge transfer. The company has established training centers,

such as the SITRAIN center, which offers specialized training programs in automation and digitalization for professionals and students.

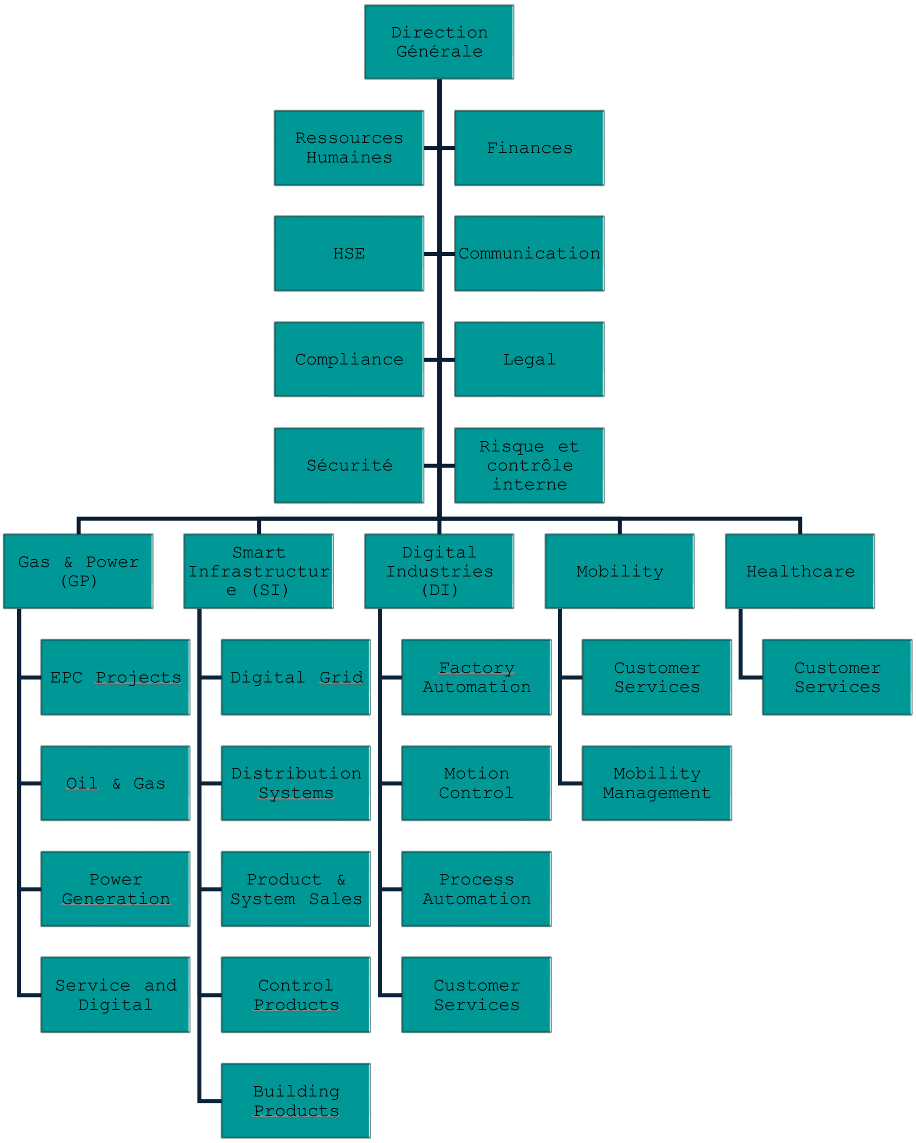
- **Engineering and Innovation Hubs**: To foster innovation and support complex projects, Siemens Algeria operates engineering hubs that focus on research and development in areas like energy automation and smart grid technologies.

This organizational structure enables Siemens Algeria to deliver comprehensive solutions across various sectors, contributing to the country's economic growth and technological advancement.

- **Organizational Chart**

In terms of organization and management, the hierarchical structure of Siemens SPA Algeria is presented as follows (see Figure 4).

Figure 6: Siemens SPA Organizational Chart



Source: Company Documents 2025

3.6. Services offered:

Siemens Algeria offers a comprehensive suite of services across various sectors, tailored to meet the specific needs of the Algerian market. Here's an overview of their key services:

a) Energy Sector:

- **Power Generation:** Siemens Algeria is a major contributor to the nation's power generation capacity, supplying advanced gas turbines, steam turbines, and complete turnkey solutions for power plants. Siemens technologies are at the heart of approximately 18% of Algeria's total installed electricity capacity. The company has played a key role in strategic energy projects such as:

- ✓ **Ras Djinet Power Plant:** Siemens delivered high-efficiency gas turbines and contributed to the engineering and commissioning phases, helping to stabilize the electricity supply in northern Algeria.
- ✓ **Aïn Arnat Power Plant (Setif):** Siemens provided critical generation technologies and operational support, enhancing energy reliability in one of Algeria's densely populated regions.
- ✓ **Biskra Power Plant:** Through the deployment of combined-cycle systems, Siemens helped improve the plant's output efficiency, aligning with Algeria's goals for cleaner and more sustainable energy generation.

In addition to hardware supply, Siemens also offers technical consulting services during the planning and construction phases, ensuring that each project meets international standards of performance, safety, and sustainability.

- **Maintenance Services:**

To support the longevity and efficiency of installed systems, Siemens Algeria established a state-of-the-art Maintenance and Repair Center located in Hammadi, Boumerdès. This facility:

- ✓ Specializes in the overhaul, inspection, and repair of gas turbines, steam turbines, and compressors.
- ✓ Provides rapid response services for unplanned maintenance events, significantly reducing downtime for clients.
- ✓ Offers upgrading and retrofitting services to modernize aging equipment and enhance performance.
- ✓ Trains and certifies Algerian engineers and technicians, fostering local expertise and workforce development.
- ✓ Serves as a regional hub, enabling Siemens to support neighboring North African countries as well.

This local presence reduces Algeria's dependency on foreign repair services, lowers operational costs for energy producers, and strengthens national energy security. Furthermore, by integrating predictive maintenance and digital diagnostics (based on Siemens' MindSphere and related IoT platforms), the center provides clients with data-driven strategies for optimizing asset lifecycles.

b) Industrial Automation and Digitalization:

- **Automation Solutions**: Siemens provides automation technologies to optimize industrial processes, enhancing efficiency and productivity across various sectors.
- **Digital Transformation**: Through partnerships with institutions like the Centre de Development of Advanced Technologies (CDTA), Siemens develops software applications that improve performance and reliability in industrial operations.

c) Healthcare Services:

- **Medical Equipment**: Siemens Healthineers supplies advanced medical imaging and diagnostic equipment to Algerian healthcare facilities, including over a hundred imaging systems.
- **Oncology Services**: In collaboration with Varian Medical Systems, Siemens established Siemens Healthineers Oncology Services Algeria (SHOSA) to provide specialized oncology solutions.

d) Transportation and Mobility:

- **Urban Transport**: Siemens played a pivotal role in the development of the Algiers metro, providing signaling and telecommunications solutions.
- **Railway Signaling**: Through a joint venture with the National Railway Transport Company (SNTF), Siemens offers advanced signaling systems for railway lines, enhancing safety and efficiency.

e) Smart Infrastructure:

- **Building Technologies**: Siemens provides solutions for building automation, including HVAC control systems, fire detection, access control, and energy management systems, contributing to the development of smart buildings in Algeria.

f) Smart Grid and Grid Software Services:

Siemens Algeria offers advanced solutions for energy automation and smart grid management, including:

- **Protection and Control Systems**: Utilizing technologies like SIPROTEC and Reyrolle, Siemens enables rapid detection and isolation of electrical faults, ensuring safety and grid stability.
- **Automation and Telecontrol**: The SICAM platform allows for remote monitoring and automation of substations, enhancing the reliability of power distribution.
- **Power Quality and Measurement**: Siemens provides tools to monitor and evaluate grid quality, ensuring consistent power delivery.

- **Digital Services and Consulting**: Offering services such as operational support, system upgrades, IT security, and training, Siemens tailors its solutions to meet specific client needs.

➢ **Local Initiatives and Infrastructure**

To bolster its smart grid capabilities in Algeria, Siemens has established:

- **Engineering Centers**: A regional engineering center focused on Digital Grid solutions, contributing to projects across Africa and Europe.
- **Training Programs**: Collaborations with local institutions to train engineers in grid automation and digital technologies, fostering local expertise.

Through these services and initiatives, Siemens Algeria plays a pivotal role in enhancing the nation's energy infrastructure, promoting sustainability, and supporting the integration of renewable energy sources.

CHAPTER III: RESULTS AND DISCUSSION

This chapter is dedicated to the analysis of the data collected through the questionnaire focused on evaluating the impact of Public-Private Partnerships (PPPs) on energy transition in Algeria, particularly through the integration of Grid Software solutions in collaboration with institutions such as Siemens and Sonelgaz.

In the first section, we present the profile and structure of the study sample. Then, we conduct preliminary analyses to ensure our dataset is suitable for multivariate analysis. Finally, in the second section, we test the research hypotheses using multiple linear regression models.

I. PRESENTATION OF RESULTS

This section presents the analysis of survey responses and the testing of hypotheses.

1. Sample Description

The total number of valid responses analyzed in this study is 70. The demographic distribution shows that the majority of participants are male (91.4%), while female respondents represent only 8.6% of the sample.

Regarding age distribution, most respondents are between 35 and 44 years old (44.29%) and between 25 and 34 years old (32.86%). A smaller proportion of participants fall under the age group of 45–54 (8.57%), under 25 years old (12.86%), and only 1.43% are 55 and above.

In terms of sectoral affiliation, 57.14% of respondents work in the private sector, while 42.86% are employed in the public sector.

As for educational attainment, the sample is highly educated: 80% hold a Master's degree, followed by 12.86% with a Bachelor's degree. Senior Technicians account for 4.29%, while Doctorate and PhD holders each represent 1.43% of the respondents.

When it comes to experience in the energy and infrastructure fields, the results show an equal split: 31.43% of respondents have between 1–3 years of experience, and another 31.43% have more than 7 years. 28.57% have 4–7 years of experience, while only 8.57% have less than 1 year of experience.

The following table provides a detailed summary of the demographic profile:

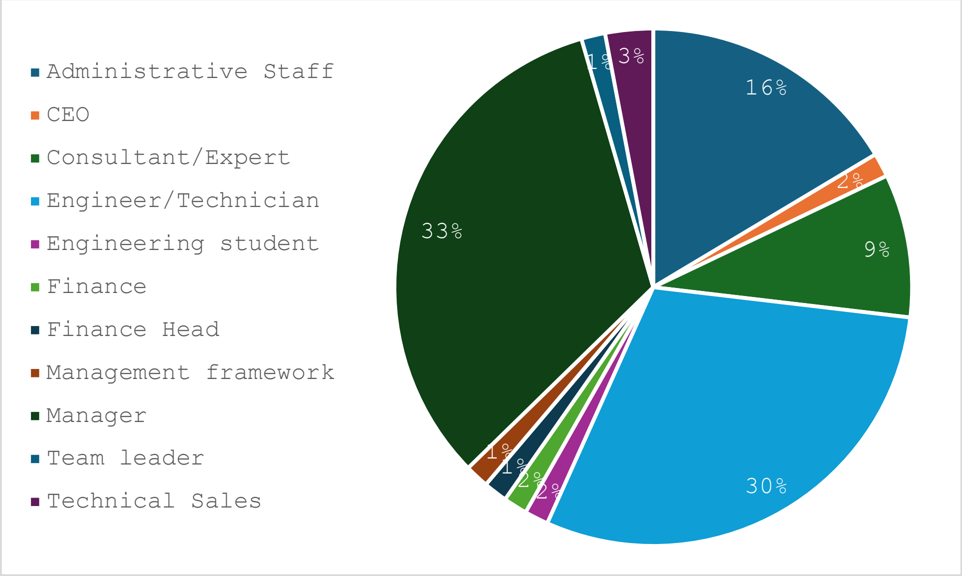
Table 4: Sample profile

Variable\Statistic	*Categories*	*Frequency per category*	*Rel. frequency per category (%)*
Age	25–34	23,000	32,857
	35–44	31,000	44,286
	45–54	6,000	8,571
	55 and above	1,000	1,429
	Under 25	9,000	12,857
Gender	Female	6,000	8,571
	Male	64,000	91,429
Sector	Private	40,000	57,143
	Public	30,000	42,857
Level of Education	Bachelor's	9,000	12,857
	Doctorate	1,000	1,429
	Master's	56,000	80,000
	PhD	1,000	1,429
	Senior Technician	3,000	4,286
Years of Experience in Energy/Infrastructure	1–3	22,000	31,429
	4–7	20,000	28,571
	Less than 1	6,000	8,571
	More than 7	22,000	31,429

Source: Developed through personal efforts using XLSTAT software

The chart below provides a breakdown of respondents' professional roles. The most common roles include Managers 22 respondents and Engineers/Technicians 20 respondents. Other notable roles include Consultants/Experts 6, Administrative staff 11, and Technical Sales 2. The sample also includes representatives from executive and student positions.

Figure 7: Respondents' professional current roles

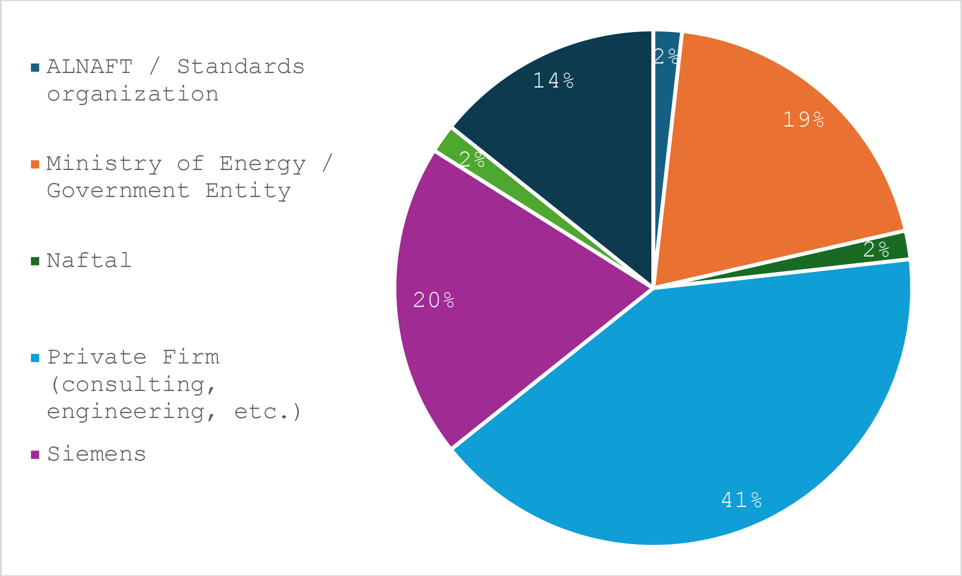


Source: Developed through personal efforts using Excel software

Moreover, the organizations represented in the survey are diverse, ranging from major public institutions like the Ministry of Energy and Sonelgaz, to multinational private firms such as Siemens and engineering consultancies. The largest proportion 23 respondents are from private firms involved in consulting and engineering, followed by representatives from Siemens 11 and the Ministry of Energy 11.

The following figure illustrates the different organization/affiliation included in our sample:

Figure 8: Respondents' professional current roles



Source: Developed through personal efforts using Excel software

1.1. Role in PPP Projects and Training Background

Table 2 below summarizes the respondents' involvement in PPP projects and their training background.

The majority of the respondents (58.57%) are core stakeholders in the PPP initiatives, including representatives from Siemens, Sonelgaz, and the Ministry of Energy. Another 15.71% represent institutions or regulatory bodies providing support. Technical and standards partners account for 11.43%. The rest of the roles are distributed among independent actors, executing firms, engineers, and installers.

Regarding primary training, most respondents come from engineering (38.57%) and economics/management (28.57%) backgrounds. Technical training accounts for 17.14%, administrative for 12.86%, and a small minority are trained in e-government and environmental disciplines.

Participation in PPP projects is also notable: 50% of the respondents indicated involvement as a private entity, while 37.14% are involved as public entities. Only 12.86% of respondents reported no involvement in PPP initiatives.

Table 5: Participation in PPP projects and training background

Variable\Statistic	*Mode frequency*	*Categories*	*Frequency per category*	*Rel. frequency per category (%)*
Role in the Public-Private Partnership (PPP) Project	41	Core Stakeholder (Siemens, Sonelgaz, Ministry)	41,000	58,571
		Engineer	1,000	1,429
		Executing firm	1,000	1,429
		Independent	2,000	2,857
		Installer	1,000	1,429
		Institutional/Regulatory Support	11,000	15,714
		International Energy Project Developer / Investment	1,000	1,429
		No	1,000	1,429
		No role	1,000	1,429
		None	1,000	1,429
		Other	1,000	1,429
		Technical/Standards Partner (ALNAFT, engineering firms)	8,000	11,429
Primary Training Area	27	Administrative	9,000	12,857
		E-Government	1,000	1,429
		Economics/Management	20,000	28,571
		Engineering	27,000	38,571
		Environment	1,000	1,429
		Technical	12,000	17,143
Involvement in public-private partnership Project	35	No	9,000	12,857
		Yes, private entity	35,000	50,000
		Yes, public entity	26,000	37,143

Source: Developed through personal efforts using XLSTAT software

2. Descriptive Univariate Analysis

2.1. Analysis of the Study

In this section, we present the univariate descriptive statistics derived from the responses to our questionnaire. We begin with the eligibility statistics of the respondents, which helped us filter relevant participants for the core analysis. The survey was conducted in two languages: French (69.4%) and English (30.6%).

Filtering Question: Have you ever been involved or participated in an Energy Transition/Smart Grid Project?

Table 6: Participation in Energy Transition/Smart Grid Projects

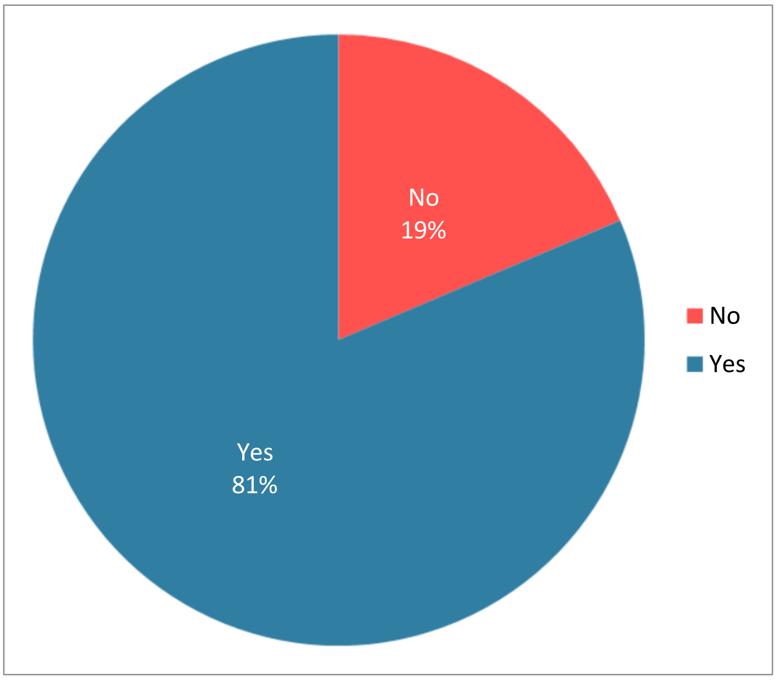
Variable\Statistic	Mode frequency	Categories	Frequency per category	Rel. frequency per category (%)
Have you ever been involved or participated in Energy Transition/Smart-Grid Project?	70	No	16,000	18,605
		Yes	70,000	81,395

Source: Developed through personal efforts using XLSTAT software

Majority Involved: The analysis reveals that a substantial majority of respondents (81.4%) have previously participated in an energy transition or smart grid project. This indicates that most participants possess relevant experience or exposure to the subject matter, enhancing the reliability of the study results.

Non-Involved Respondents: Meanwhile, 18.6% of participants reported no prior involvement in such projects. While these respondents were filtered out from the core analytical phase, their inclusion at the initial stage underscores the reach of the survey and ensures a broad data collection effort.

Figure 9: Participation in Energy Transition/Smart Grid Projects



Source: Developed through personal efforts using XLSTAT software

2.2. Analysis of the Core Constructs

In this section, we present the descriptive univariate analyses of the key theoretical constructs mobilized in the study. These constructs are measured using a 5-point Likert scale, measuring respondents' perceptions of the effectiveness of public-private partnerships (PPPs), the impact of grid software, its role in energy transition, and the influence of regulatory and financial barriers. Each table and graph summarizes the average response score for the related items. The higher the average, the more the respondents perceive the concept in question as significant or impactful. The standard deviation is also presented to indicate the dispersion of responses.

2.2.1. Effectiveness of Public-Private Partnerships

This construct evaluates to what extent PPPs specifically the Siemens–Sonelgaz partnership are perceived to enhance the deployment of smart grid software through funding, risk-sharing, and operational efficiency.

➢ **Perceived PPP Effectiveness**

The table below confirms that PPPs are perceived positively in terms of supporting smart grid software deployment. The highest score (mean equal to 3,929 and SD equal to 0,961) is related to the long-term operational efficiency ensured by collaboration through PPPs. This suggests that respondents strongly believe in the added value of these partnerships.

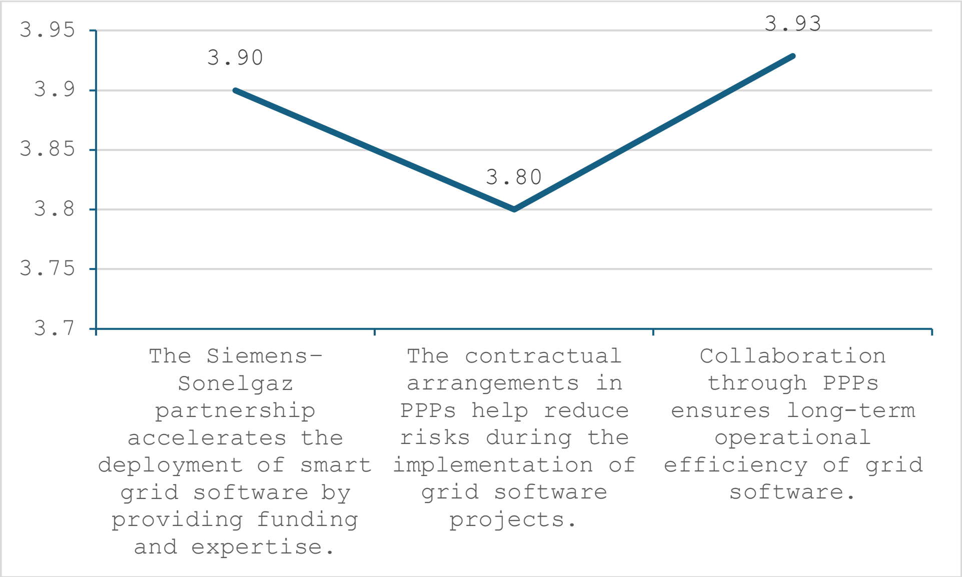
These results indicate that PPPs are widely perceived as effective mechanisms for facilitating the deployment of smart grid software, although the overall level of agreement is slightly below "strong agreement" on the Likert scale. Moderate standard deviations (ranging from 0.961 to 1.084) also reflect a relatively consistent view among respondents.

Table 7: Average score for PPP effectiveness on grid software deployment

Statistic	The Siemens–Sonelgaz partnership accelerates the deployment of smart grid software by providing funding and expertise.	The contractual arrangements in PPPs help reduce risks during the implementation of grid software projects.	Collaboration through PPPs ensures long-term operational efficiency of grid software.
Nbr. Of observations	70	70	70
Median	4,000	4,000	4,000
Mean	3,900	3,800	3,929
Standard deviation (n-1)	1,084	0,994	0,961

Source: Developed through personal efforts using SPSS software

Figure 10: Average score for PPP effectiveness on grid software deployment



Source: Developed through personal efforts using Excel software

2.2.2. Grid Software's Impact on Renewable Integration and Decarbonization

This part evaluates how respondents perceive the contribution of grid software to renewable energy integration, CO_2 emission reductions, and the stabilization of grid parameters under variable generation.

- **Technical Performance of Grid Software**

In the table below the evaluation of grid software capabilities shows moderate to high average scores across the items, particularly for its role in reducing CO_2 emissions (mean equal to 3,800 and SD equal to 1,103) and supporting the integration of more renewable energy (mean equal to 3,771 and SD equal to 1,017). The item related to stabilizing voltage and frequency has a slightly lower mean of 3.743 with an SD of 1,065, but still reflects a generally favorable perception.

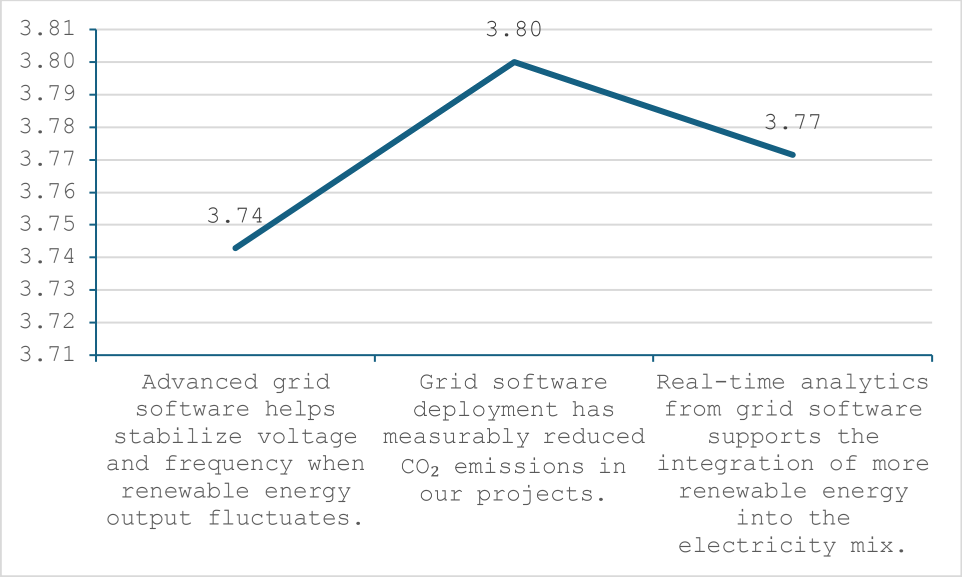
These results highlight that respondents recognize the operational value of advanced grid software, especially in contributing to decarbonization and renewable energy integration. However, the relatively high standard deviations suggest some variability in opinions.

Table 8: Average score for grid software's impact on energy transition

Statistic	Advanced grid software helps stabilize voltage and frequency when renewable energy output fluctuates.	Grid software deployment has measurably reduced CO_2 emissions in our projects.	Real-time analytics from grid software supports the integration of more renewable energy into the electricity mix.
Nbr. Of observations	70	70	70
Median	4,000	4,000	4,000
Mean	3,743	3,800	3,771
Standard deviation (n-1)	1,065	1,103	1,017

Source: Developed through personal efforts using SPSS software

Figure 11: Average score for grid software's impact on energy transition



Source: Developed through personal efforts using Excel software

2.2.3. Contribution of PPP-Based Grid Software to the Energy Transition

This block reflects the respondents' view on whether the Siemens–Sonelgaz partnership and its deployment of grid software contribute to Algeria's broader decarbonization and energy transition goals.

- **Alignment with Energy Transition Goals**

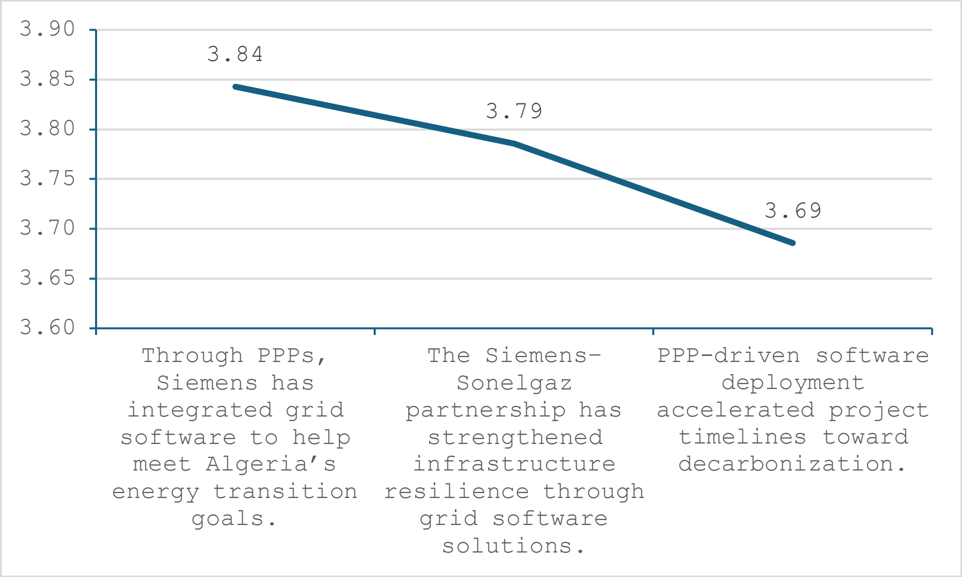
This dimension in the table below evaluates the overall contribution of PPPs and grid software to achieving Algeria's energy transition goals. The statement regarding Siemens–Sonelgaz partnership strengthening infrastructure resilience received the highest agreement (mean equal to 3,786 and SD equal to 1,054), closely followed by the perception that PPPs have integrated grid software to support national energy goals (mean equal to 3,843 and SD equal to 1,104). The lowest, though still favorable, mean score was recorded for PPP-driven acceleration of decarbonization timelines (mean equal to 3.686 and SD equal to 1.063).

Table 9: Average score for PPP contribution to energy transition

Statistic	Through PPPs, Siemens has integrated grid software to help meet Algeria's energy transition goals.	The Siemens–Sonelgaz partnership has strengthened infrastructure resilience through grid software solutions.	PPP-driven software deployment accelerated project timelines toward decarbonization.
Nbr. Of observations	70	70	70
Median	4,000	4,000	4,000
Mean	3,843	3,786	3,686
Standard deviation (n-1)	1,104	1,054	1,063

Source: Developed through personal efforts using SPSS software

Figure 12: Average score for PPP contribution to energy transition



Source: Developed through personal efforts using Excel software

2.2.4. Moderating Role of Regulatory and Financial Barriers

This section explores the extent to which regulatory and financial constraints hinder PPP performance in grid software deployment.

- **Perceived Barriers**

In the table below the analysis of moderating factors highlights significant concerns among respondents. The perception that regulatory complexity delays grid software implementation received the highest mean score (mean equal to 4.014 and SD equal to 0.964), underlining the impact of bureaucratic and legal obstacles. High investment costs also emerged as a notable barrier (mean equal to 3.657, and SD equal to 1.040), reinforcing the idea that financial constraints remain a challenge.

Notably, financial incentives within PPPs recorded the lowest mean score (mean equal to 3.929 and SD equal to 0.976), suggesting that while such mechanisms exist, they may not sufficiently mitigate investment risk in the eyes of stakeholders.

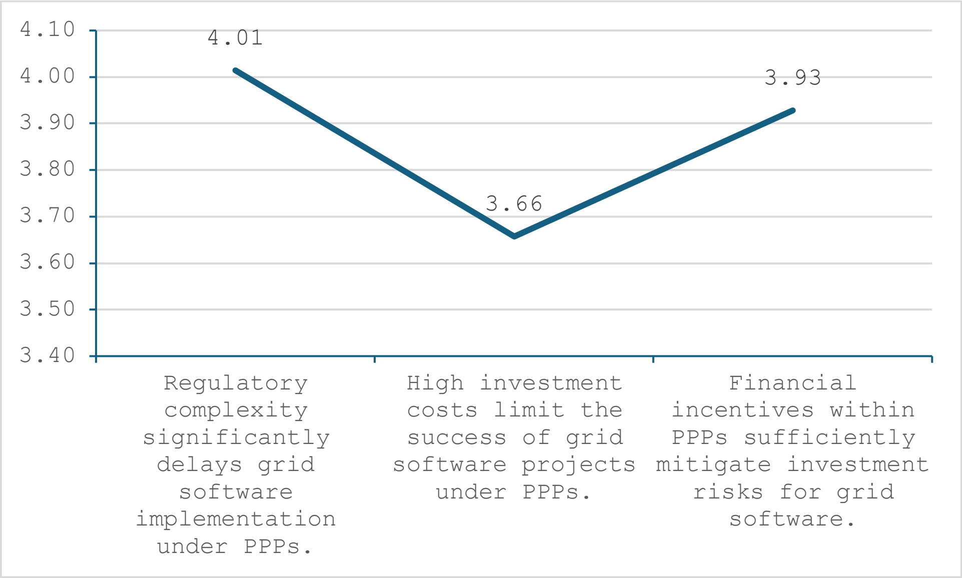
These insights suggest that although PPPs are largely effective, their success is moderated by significant regulatory and financial barriers that need to be addressed for smoother implementation and broader impact.

Table 10: Average score for regulatory and financial barriers

Statistic	Regulatory complexity significantly delays grid software implementation under PPPs.	High investment costs limit the success of grid software projects under PPPs.	Financial incentives within PPPs sufficiently mitigate investment risks for grid software.
Nbr. Of observations	70	70	70
Median	4,000	4,000	4,000
Mean	4,014	3,657	3,929
Standard deviation (n-1)	0,964	1,040	0,976

Source: Developed through personal efforts using SPSS software

Figure 13: Average score for regulatory and financial barriers



Source: Developed through personal efforts using Excel software

3. Preliminary Analyses of Data Suitability for Multivariate Analysis

Before proceeding with the analysis of the data collected from our sample, it is essential to assess the suitability of the data for multivariate analysis. This preliminary step involves checking for missing values, evaluating the approximate normality of the data, and examining multicollinearity.

3.1. Missing Values

Missing data must be addressed before conducting any advanced statistical analyses, typically using various imputation or exclusion methods. In this study, we collected complete questionnaires only, thanks to the online administration mode and the use of the mandatory response setting in the questionnaire tool. As a result, no missing values were recorded.

3.2. Approximate Normality of the Data

To ensure the validity of multivariate analyses, we verified whether our dataset follows an approximately normal distribution (univariate normality) by inspecting Skewness and Kurtosis coefficients. Acceptable ranges for these indicators are between [-1; +1] for Skewness and [1.5; +1.5] for Kurtosis. The results show that all variables fall within these acceptable ranges, confirming a satisfactory level of univariate quasi-normality. in the table below a summary of the findings:

Table 11: Quasi-Normality (Skewness and Kurtosis Tests)

STATISTIC	MEAN	STANDARD DEVIATION (N-1)	SKEWNESS (PEARSON)	KURTOSIS (PEARSON)
THE SIEMENS–SONELGAZ PARTNERSHIP ACCELERATES THE DEPLOYMENT OF SMART GRID SOFTWARE BY PROVIDING FUNDING AND EXPERTISE.	3,900	1,092	-0,944	0,311
THE CONTRACTUAL ARRANGEMENTS IN PPPS HELP REDUCE RISKS DURING THE IMPLEMENTATION OF GRID SOFTWARE PROJECTS.	3,800	1,001	-0,638	0,101
COLLABORATION THROUGH PPPS ENSURES LONG-TERM OPERATIONAL EFFICIENCY OF GRID SOFTWARE.	3,929	0,968	-0,630	-0,121
ADVANCED GRID SOFTWARE HELPS STABILIZE VOLTAGE AND FREQUENCY WHEN RENEWABLE ENERGY OUTPUT FLUCTUATES.	3,743	1,073	-0,610	-0,343
GRID SOFTWARE DEPLOYMENT HAS MEASURABLY REDUCED CO_2 EMISSIONS IN OUR PROJECTS.	3,800	1,111	-0,748	-0,115
REAL-TIME ANALYTICS FROM GRID SOFTWARE SUPPORTS THE INTEGRATION OF MORE RENEWABLE ENERGY INTO THE ELECTRICITY MIX.	3,771	1,024	-0,837	0,489
THROUGH PPPS, SIEMENS HAS INTEGRATED GRID SOFTWARE TO HELP MEET ALGERIA'S ENERGY TRANSITION GOALS.	3,843	1,112	-0,771	-0,066
THE SIEMENS–SONELGAZ PARTNERSHIP HAS STRENGTHENED INFRASTRUCTURE RESILIENCE THROUGH GRID SOFTWARE SOLUTIONS.	3,786	1,062	-0,662	-0,213
PPP-DRIVEN SOFTWARE DEPLOYMENT ACCELERATED PROJECT TIMELINES TOWARD DECARBONIZATION.	3,686	1,071	-0,348	-0,564
REGULATORY COMPLEXITY SIGNIFICANTLY DELAYS GRID SOFTWARE IMPLEMENTATION UNDER PPPS.	4,014	0,970	-0,987	0,919
HIGH INVESTMENT COSTS LIMIT THE SUCCESS OF GRID SOFTWARE PROJECTS UNDER PPPS.	3,657	1,048	-0,346	-0,754
FINANCIAL INCENTIVES WITHIN PPPS SUFFICIENTLY MITIGATE INVESTMENT RISKS FOR GRID SOFTWARE.	3,929	0,983	-0,595	-0,259

Source: Developed through personal efforts using XLSTAT software

All values meet the normality assumptions required for subsequent parametric and multivariate analyses, confirming the statistical adequacy of the dataset for further exploration.

3.3. Multicollinearity

The absence of multicollinearity was assessed using Variance Inflation Factors (VIF) and Tolerance values. According to standard thresholds, VIF values below 10 and Tolerance values close to or above 0.3 indicate that multicollinearity is not a concern. The results of our data analysis confirm that there is no significant multicollinearity between the variables included in the table below:

Table 12: Multicollinearity (Tolerance + VIF)

STATISTIC	TOLERANCE	VIF
THE SIEMENS–SONELGAZ PARTNERSHIP ACCELERATES THE DEPLOYMENT OF SMART GRID SOFTWARE BY PROVIDING FUNDING AND EXPERTISE.	0,614	1,628
THE CONTRACTUAL ARRANGEMENTS IN PPPS HELP REDUCE RISKS DURING THE IMPLEMENTATION OF GRID SOFTWARE PROJECTS.	0,585	1,708
COLLABORATION THROUGH PPPS ENSURES LONG-TERM OPERATIONAL EFFICIENCY OF GRID SOFTWARE.	0,626	1,599
ADVANCED GRID SOFTWARE HELPS STABILIZE VOLTAGE AND FREQUENCY WHEN RENEWABLE ENERGY OUTPUT FLUCTUATES.	0,580	1,725
GRID SOFTWARE DEPLOYMENT HAS MEASURABLY REDUCED CO_2 EMISSIONS IN OUR PROJECTS.	0,541	1,850
REAL-TIME ANALYTICS FROM GRID SOFTWARE SUPPORTS THE INTEGRATION OF MORE RENEWABLE ENERGY INTO THE ELECTRICITY MIX.	0,605	1,653
REGULATORY COMPLEXITY SIGNIFICANTLY DELAYS GRID SOFTWARE IMPLEMENTATION UNDER PPPS.	0,530	1,886
HIGH INVESTMENT COSTS LIMIT THE SUCCESS OF GRID SOFTWARE PROJECTS UNDER PPPS.	0,677	1,478
FINANCIAL INCENTIVES WITHIN PPPS SUFFICIENTLY MITIGATE INVESTMENT RISKS FOR GRID SOFTWARE.	0,568	1,759

Source: Developed through personal efforts using XLSTAT software

All Tolerance values are above 0.5, and VIF values range between 1.478 and 1.886, which are well below the critical threshold of 10. These results clearly indicate that no significant multicollinearity issues are present in the dataset.

These preliminary findings confirm that the dataset is adequate for subsequent multivariate analyses.

4. Principal Component Analysis (PCA)

We conducted Principal Component Analyses (PCA) to verify the validity and reliability of our measurement scales. Recommended thresholds from the literature were adopted for this evaluation. For factor loadings, we retained only correlations higher than 0.5, communalities above 0.6, and loadings greater than 0.5.

We considered 60% as the minimum acceptable threshold for total variance explained and required a KMO (Kaiser-Meyer-Olkin) value above 0.6.

The Bartlett's test of sphericity, which examines the null hypothesis that all correlations are equal to zero, had to be significant at an alpha level of 0.05. While the test is sensitive to sample size, it was statistically significant in all cases in our analysis.

The reliability of the measurement scales was evaluated using Cronbach's Alpha. A minimum threshold of 0.7 was applied to assess internal consistency.

We set the number of extracted factors for each dimension to one to allow for subsequent linear regression hypothesis testing.

All PCA results for the study variables are summarized in Table 25.

4.1. Measurement Scale of PPP Effectiveness

A Principal Component Analysis (PCA) was conducted on all items related to the PPP Effectiveness construct. The results indicated a moderate correlation (greater than 0.5) among the items used within this dimension.

By performing the PCA on this variable composed of three items, we observed that the total variance explained allows for the retention of a single component (one factor) with an eigenvalue greater than 1, which alone explains 66.514% of the initial information. The results are presented in Table 13 below:

Table 13: Total Variance Explained of PPP Effectiveness

Component	**Initial Eigenvalues**	**Extraction Sums of Squared Loadings**
	Total	% of Variance
1	1.995	66.514
2	0.527	17.569
3	0.478	15.917

Source: Developed through personal efforts using XLSTAT software

The component matrix showed that all items were moderately correlated with each other. The highest factor loading was found for the item “Collaboration through PPPs ensures long-term operational efficiency of grid software” with a KMO value of 0.700.

The KMO index for the entire scale was 0.690, indicating an acceptable level of sampling adequacy. This implies that the partial correlations between the items are satisfactory. Additionally, Bartlett’s Test of Sphericity was significant ($p < 0.0001$), suggesting that the data is appropriate for factor analysis. The test results are summarized in Table 14:

Table 14: KMO and Bartlett’s Test of PPP Effectiveness

Test	**Value**
Kaiser-Meyer-Olkin Measure	0.690
Bartlett’s Test of Sphericity (χ^2)	46.261
Degrees of Freedom	3
Significance (p-value)	< 0.0001

Source: Developed through personal efforts using XLSTAT software

The component matrix confirmed that all items had good factor loadings. Therefore, we retained all items for subsequent analysis.

The reliability test showed that the internal consistency of the scale is acceptable, with a Cronbach’s alpha of 0.747, which is above the minimum threshold of 0.70. These results are presented in Table 15:

Table 15: Reliability Statistics of PPP Effectiveness

Statistic	**Value**
Cronbach’s Alpha	0.747
Standardized Cronbach’s Alpha	0.748
Number of Items	3

Source: Developed through personal efforts using XLSTAT software

4.2. Measurement Scale of Grid Software’s Impact on Energy Transition

A Principal Component Analysis (PCA) was performed on all items related to the variable Grid Software’s Impact on Energy Transition. The results revealed a moderate to strong correlation (above 0.5) among the three items used to measure this dimension.

The PCA results confirmed that the total variance explained supports the retention of a single component, with an eigenvalue above 1, which explains 70.246% of the total variance. This indicates that a single factor captures the majority of the information from the items. The detailed results are presented in Table 16 below:

Table 16: Total Variance Explained of Grid Software’s Impact on Energy Transition

Component	Initial Eigenvalues	Extraction Sums of Squared Loadings
	Total	% of Variance
1	2.107	70.246
2	0.476	15.853
3	0.417	13.902

Source: Developed through personal efforts using XLSTAT software

All three items showed adequate factor loadings. The highest individual KMO value was 0.723 for the item “Real-time analytics from grid software supports the integration of more renewable energy into the electricity mix”, indicating strong sampling adequacy at the item level.

The overall KMO index was 0.705, which indicates that the data is suitable for factor analysis. The Bartlett’s Test of Sphericity was also significant ($p < 0.0001$), confirming the appropriateness of applying PCA. Table 17 summarizes these results:

Table 17: KMO and Bartlett's Test of Grid Software's Impact on Energy Transition

Test	Value
Kaiser-Meyer-Olkin Measure	0.705
Bartlett's Test of Sphericity (χ^2)	58.591
Degrees of Freedom	3
Significance (p-value)	< 0.0001

Source: Developed through personal efforts using XLSTAT software

Since all factor loadings were acceptable and the variance explained was high, all items were retained for further analysis.

Regarding the reliability of the scale, the Cronbach's alpha coefficient was 0.788, exceeding the commonly accepted threshold of 0.70. This indicates that the internal consistency of the scale is satisfactory. The results are presented in Table 18:

Table 18: Reliability Statistics of Grid Software's Impact on Energy Transition

Statistic	Value
Cronbach's Alpha	0.788
Standardized Cronbach's Alpha	0.788
Number of Items	3

Source: Developed through personal efforts using XLSTAT software

4.3. Measurement Scale of PPP-Based Grid Software Contribution to Energy Transition

A Principal Component Analysis (PCA) was conducted on the items measuring the variable PPP-Based Grid Software Contribution to Energy Transition. The analysis revealed a moderate to strong correlation among all three items, each exhibiting a KMO value above 0.69, confirming the adequacy of the data for factor analysis.

The PCA results show that one single component was retained, as its eigenvalue exceeds 1, and it alone explains 71.484% of the total variance. This confirms the unidimensional structure of the construct. The results are detailed in Table 19 below:

Table 19: Total Variance Explained of PPP-Based Grid Software Contribution

Component	**Initial Eigenvalues**	**Extraction Sums of Squared Loadings**
	Total	% of Variance
1	2.145	71.484
2	0.453	15.114
3	0.402	13.402

Source: Developed through personal efforts using XLSTAT software

All three items loaded strongly onto the retained factor, with the highest KMO item-level value being 0.731 for the item "PPP-driven software deployment accelerated project timelines toward decarbonization." The overall KMO index of 0.710 indicates a good level of sampling adequacy, justifying the use of PCA. The Bartlett's Test of Sphericity was also statistically significant ($p < 0.0001$), supporting the appropriateness of the factor model. These findings are shown in Table 20:

Table 20: KMO and Bartlett's Test of PPP-Based Grid Software Contribution

Test	Value
Kaiser-Meyer-Olkin Measure	0.710
Bartlett's Test of Sphericity (χ^2)	63.081
Degrees of Freedom	3
Significance (p-value)	< 0.0001

Source: Developed through personal efforts using XLSTAT software

Given that all items have strong factor loadings and the component explains more than 70% of the variance, all items are retained for further analysis.

To evaluate internal consistency, the Cronbach's alpha was calculated and found to be 0.800, which exceeds the acceptable reliability threshold. This demonstrates that the scale has good internal consistency. The results are presented in Table 21:

Table 21: Reliability Statistics of PPP-Based Grid Software Contribution

Statistic	Value
Cronbach's Alpha	0.800
Standardized Cronbach's Alpha	0.800
Number of Items	3

Source: Developed through personal efforts using XLSTAT software

4.4. Measurement Scale of Regulatory and Financial Barriers

To assess the construct validity of the Regulatory and Financial Barriers variable, a Principal Component Analysis (PCA) was performed. The results confirm that all three items are sufficiently interrelated to justify dimensionality reduction through factor analysis. Individual KMO values ranged from 0.634 to 0.756, indicating acceptable sampling adequacy for PCA. The PCA extracted a single factor with an eigenvalue of 1.991, accounting for 66.365% of the total variance. This confirms the unidimensional nature of the scale. The results are summarized in Table 22 below:

Table 22: Total Variance Explained of Regulatory and Financial Barriers

Component	Initial Eigenvalues	Extraction Sums of Squared Loadings
	Total	% of Variance
1	1.991	66.365
2	0.605	20.168
3	0.404	13.467

Source: Developed through personal efforts using XLSTAT software

The overall KMO index for this scale was 0.667, which is considered acceptable for factor analysis. The Bartlett's Test of Sphericity yielded a statistically significant result ($\chi^2 = 48.370$, $p < 0.0001$), further confirming the suitability of PCA for this variable. These results are detailed in Table 23:

Table 23: KMO and Bartlett's Test of Regulatory and Financial Barriers

Test	Value
Kaiser-Meyer-Olkin Measure	0.667
Bartlett's Test of Sphericity (χ^2)	48.370
Degrees of Freedom	3
Significance (p-value)	< 0.0001

Source: Developed through personal efforts using XLSTAT software

All three items exhibited adequate communalities and factor loadings on the extracted component. Given that the retained factor explains more than 66% of the variance, no items were excluded.

The internal consistency of the scale was assessed using Cronbach's Alpha. The result of 0.743 confirms that the three items form a reliable and coherent measurement scale. This is summarized in Table 24:

Table 24: Reliability Statistics of Regulatory and Financial Barriers

Statistic	**Value**
Cronbach's Alpha	0.743
Standardized Cronbach's Alpha	0.745
Number of Items	3

Source: Developed through personal efforts using XLSTAT software

Table 25: Summary Table of Principal Component Analysis for Study Variables

Study Variable	**KMO**	**Sig**	**Components**	**Total Variance Explained (%)**	**Eigenvalue**	**Cronbach's Alpha**
PPP Effectiveness	0.690	0.000	1	66.514	1.995	0.747
Grid Software's Impact on Energy Transition	0.705	0.000	1	70.246	2.107	0.788
PPP-Based Grid Software Contribution to Transition	0.710	0.000	1	71.484	2.145	0.800
Regulatory and Financial Barriers	0.667	0.000	1	66.365	1.991	0.743

Source: Developed through personal efforts using XLSTAT software

5. Hypothesis Testing

We tested the hypotheses of our research using multiple linear regressions. The type of variables used in our theoretical model (quantitative scales) allowed us to conduct this type of analysis. The thresholds and coefficients recommended for validating this method included the significance level of the ANOVA test, which had to be less than 0.05 (5%). This threshold was used to assess whether the R^2 (coefficient of determination) was significantly different from zero.

The regression method used for hypothesis testing in this study was the Enter method (also known as the standard method), where all predictors were entered into the model simultaneously.

5.1. Public-Private Partnerships positive impact on grid software development (H1)

Hypothesis 1 was tested using a simple linear regression analysis where the average perception of Public-Private Partnerships (PPP) was considered as the independent variable, and the development of Grid Software was the dependent variable. The statistical outputs of the regression model are shown in Table 26 below:

Table 26: Model Summary of Linear Regression of Hypothesis 1

Model	**R**	**R^2**	**Adjusted R^2**	**RMSE**	**R^2 Change**	**F Change**	**df1**	**df2**	**Sig. F Change**	**Durbin-Watson**
M_1	0.130	0.017	0.002	0.895	0.017	1.166	1	68	0.284	2.545

Source: Developed through personal efforts using JASP Outputs

- The R value of 0.130 indicates a very weak positive correlation between Public-Private Partnerships and Grid Software development.
- The R^2 value of 0.017 means that only 1.7% of the variance in Grid Software development is explained by PPPs.
- The Adjusted R^2 of 0.002 shows that when accounting for the number of predictors, the explained variance is even lower, reinforcing the weak explanatory power of the model.

- The Durbin-Watson statistic of 2.545 is relatively close to 2, indicating an acceptable level of autocorrelation in the residuals and a normally distributed error term.

The ANOVA table (Table 27) presents the significance of the regression model as a whole:

Table 27: ANOVA of Hypothesis 1

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.935	1	0.935	1.166	0.284
Residual	54.519	68	0.802		
Total	55.454	69			

Source: Developed through personal efforts using JASP Outputs

- The F-value of 1.166 with a p-value of 0.284 indicates that the model is not statistically significant at the 0.05 level. Therefore, the regression model does not provide sufficient evidence to support a significant impact of PPPs on Grid Software development.

The coefficients table (Table 28) presents the influence of PPP on the dependent variable:

Table 28: Regression Coefficients of Hypothesis 1

Model	Unstandardized Coefficient (B)	Std. Error	Standardized Beta (β)	t	Sig
M_1	0.140	0.129	0.130	1.080	0.284

Source: Developed through personal efforts using JASP Outputs

- The coefficient β of 0.130 for PPP is not statistically significant ($p = 0.284 > 0.05$), indicating that variations in PPP are not associated with significant changes in the development of Grid Software.

Based on the regression results, the hypothesis H1 regarding the positive impact of Public-Private Partnerships on Grid Software development is not supported by the data. The model's explanatory power is weak, and the relationship between the variables is not statistically significant.

Therefore, H1 is rejected.

5.2. The Impact of Grid Software on Energy Transition Efficiency (H2)

Hypothesis 2 aimed to test whether the implementation of grid software solutions positively influences the efficiency of energy transition efforts. A simple linear regression was conducted using the average perception of grid software (GS) as the independent variable and energy transition efficiency as the dependent variable. The results are summarized in Table 29 below:

Table 29: Model Summary of Linear Regression of Hypothesis 2

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	Sig
M_1	0.360	0.129	0.117	0.859	0.129	10.106	1	68	0.002

Source: Developed through personal efforts using JASP Outputs

- The correlation coefficient R = 0.360, suggesting a moderate positive correlation between grid software usage and energy transition efficiency.
- The R^2 value = 0.129, indicating that 12.9% of the variance in energy transition efficiency is explained by grid software implementation.
- The adjusted R^2 = 0.117 confirms the model's reliability after accounting for the number of predictors.
- The Root Mean Square Error (RMSE) is 0.859, indicating relatively low error in prediction.
- The Durbin-Watson statistic = 2.847, which is close to 2 and suggests no significant autocorrelation in the residuals.
- The p-value = 0.002, which is highly significant ($p < 0.01$), indicates that the relationship is statistically significant and not due to chance.

These results provide strong support for the hypothesis that grid software plays a meaningful role in improving energy transition outcomes.

Table 30 presents the results of the ANOVA test:

Table 30: ANOVA of Hypothesis 2

Source	Sum of Squares	df	Mean Square	F	Sig
Regression	7.463	1	7.463	10.106	0.002
Residual	50.214	68	0.738		
Total	57.676	69			

Source: Developed through personal efforts using JASP Outputs

The model explains a significant portion of the variation in energy transition efficiency (F (1, 68) = 10.106, p = 0.002), confirming the strength of the relationship between the predictor and the outcome variable.

Table 31: Coefficients of Hypothesis 2

Variable	Unstandardized B	Std. Error	Standardized Beta	t	Sig
(Intercept)	2.388	0.447	–	5.340	< .001
Average GS	0.367	0.115	0.360	3.179	0.002

Source: Developed through personal efforts using JASP Outputs

The unstandardized coefficient (B = 0.367) for grid software is positive and statistically significant (p = 0.002). This confirms that as perceptions of grid software effectiveness increase, so does the perceived efficiency of the energy transition.

Conclusion:

The results support Hypothesis H2, confirming that grid software solutions have a significant positive impact on the efficiency of energy transition. The statistical significance, combined with a moderate correlation and low prediction error, strengthens the argument for integrating grid software technologies into national energy strategies.

Therefore, H2 is Valid.

The final regression model can be expressed as:

Energy Transition Efficiency = 2.388 + 0.367 × Grid Software + ε

Where:

- 2.388 is the intercept,
- 0.367 is the unstandardized coefficient for grid software,
- ε represents the error term.

This model implies that for every one-unit increase in the average grid software score, energy transition efficiency is expected to increase by approximately 0.367 units.

5.3. The Influence of PPPs on Energy Transition Through Grid Software (H3)

Hypothesis 3 proposed that Public-Private Partnerships (PPPs) positively affect energy transition performance when mediated by grid software implementation. To test this hypothesis, a multiple linear regression analysis was performed with grid software (GS) and PPPs as independent variables and energy transition efficiency as the dependent variable. The results are presented in Table 32.

Table 32: Model Summary of Multiple Linear Regression of Hypothesis 3

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	Sig
M_1	0.490	0.240	0.218	0.809	0.240	10.599	2	67	< .001

Source: Developed through personal efforts using JASP Outputs

- The correlation coefficient R = 0.490 indicates a moderate positive relationship between the predictors (PPPs and grid software) and energy transition efficiency.
- The model explains 24% of the variance ($R^2 = 0.240$) in the dependent variable, a notable improvement over the previous models.
- The adjusted R^2 of 0.218 confirms that the model remains robust when accounting for the number of predictors.
- The RMSE is 0.809, indicating an improvement in prediction accuracy.
- The F-statistic (F (2, 67) is 10.599, $p < .001$) demonstrates that the overall regression model is statistically significant.

- The Durbin-Watson statistic of 2.773, which is close to 2, suggests no significant autocorrelation in the residuals.

These findings support the claim that both PPPs and grid software together contribute significantly to improving energy transition outcomes.

Table 33 Table 30: ANOVA of Hypothesis 3

Source	Sum of Squares	df	Mean Square	F	Sig
Regression	13.862	2	6.931	10.599	< .001
Residual	43.814	67	0.654		
Total	57.676	69			

Source: Developed through personal efforts using JASP Outputs

The ANOVA results confirm that the model is statistically significant ($p < .001$), indicating that the combination of PPPs and grid software explains a significant portion of the variance in energy transition efficiency.

Table 34: Coefficients of Hypothesis 3

Variable	Unstandardized B	Std. Error	Standardized Beta	t	Sig
(Intercept)	1.126	0.583	–	1.931	0.058
Average GS	0.322	0.110	0.316	2.943	0.004
Average PPP	0.369	0.118	0.336	3.128	0.003

Source: Developed through personal efforts using JASP Outputs

- The coefficient for PPPs ($B = 0.369$) is positive and statistically significant ($p = 0.003$).
- The coefficient for grid software ($B = 0.322$) is also positive and significant ($p = 0.004$).
- Both predictors have similar standardized beta values (GS: 0.316, PPPs: 0.336), indicating they contribute comparably to the model.

The results provide strong support for Hypothesis 3, confirming that PPPs significantly influence energy transition efficiency through the role of grid software. The regression model suggests that both variables are essential and work in synergy to enhance energy transition outcomes in Algeria.

The final regression equation can be written as:

Energy Transition Efficiency = 1.126 + 0.322 × Grid Software + 0.369 × PPPs + ε

Where:

- 1.126 is the intercept,
- 0.322 and 0.369 are the unstandardized coefficients for grid software and PPPs, respectively,
- ε is the error term.

This equation indicates that for every unit increase in the perceived effectiveness of grid software and PPPs, energy transition efficiency is expected to increase by approximately 0.322 and 0.369 units respectively, holding the other constant.

5.4. The Moderating Role of Regulatory and Financial Barriers on PPP-Driven Grid Software Solutions (H4)

Hypothesis 4 tested whether regulatory and financial challenges (referred to as “fb”) moderate the relationship between Public-Private Partnerships (PPPs) and grid software effectiveness in driving the energy transition. A moderated regression analysis was conducted by introducing an interaction term between PPP and fb (i.e., PPP × fb) in the model. The results are summarized in Table 35

.

Table 35: Model Summary of Moderated Regression of Hypothesis 4

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	Sig
M_1	0.212	0.045	0.001	0.896	0.045	1.034	3	66	0.383

Source: Developed through personal efforts using JASP Outputs

- The model shows a very weak correlation (R = 0.212) between the predictors (PPP, fb, and the interaction term) and the outcome variable.
- The explained variance is minimal ($R^2 = 0.045$), and the adjusted $R^2 = 0.001$, indicating almost no improvement in model fit when accounting for the number of predictors.
- The model is not statistically significant (F (3, 66) = 1.034, p = 0.383), meaning the predictors do not jointly explain a significant portion of the variance in the outcome.

- The Durbin-Watson statistic = 2.499, which is close to 2, indicates no major issues with autocorrelation.

Table 36: ANOVA of Hypothesis 4

Source	Sum of Squares	df	Mean Square	F	Sig
Regression	2.490	3	0.830	1.034	0.383
Residual	52.964	66	0.802		
Total	55.454	69			

Source: Developed through personal efforts using JASP Outputs

The ANOVA table supports the non-significance of the overall model, further suggesting that the inclusion of fb and its interaction with PPPs does not significantly improve prediction of the energy transition outcome through grid software.

Table 37: Coefficients of Hypothesis 4

Variable	Unstandardized B	Std. Error	Standardized Beta	t	Sig
(Intercept)	2.928	3.149	–	0.930	0.356
Average PPP	0.389	0.777	0.361	0.500	0.619
Average fb	0.081	0.779	0.074	0.104	0.917
Interaction	−0.065	0.192	−0.329	−0.340	0.735

Source: Developed through personal efforts using JASP Outputs

- None of the predictors (PPP, fb, or interaction) are statistically significant.
- The interaction term (B = −0.065, p = 0.735) fails to demonstrate a moderating effect of regulatory and financial challenges on the PPP–grid software relationship.
- The very low standardized beta values and high p-values across the predictors further confirm the weakness of the model.

The analysis does not support Hypothesis 4. The results suggest that regulatory and financial challenges do not significantly moderate the relationship between PPPs and the effectiveness of grid software in advancing energy transition. Although these barriers may exist in practice, their statistical effect on this relationship is not evident in the current model.

Therefore, H4 is rejected.

These findings suggest that PPPs and grid software contribute to the energy transition (as shown in H3), although regulatory and financial constraints do not significantly alter the strength or direction of this effect at least not in a statistically measurable way, within the scope of this study.

A summary of the results obtained from the hypothesis testing is presented in Table 38 below:

Table 38: Summary of Regression Results

H	Hypothesis	Confirmation
H1	Public–Private Partnerships have a positive impact on grid software development.	Not supported
H2	Grid software solutions improve energy transition efficiency.	Supported
H3	Public–Private Partnerships positively influence energy transition through grid software.	Supported
H4	Regulatory and financial barriers moderate the effectiveness of PPP-driven grid software solutions.	Not supported

Source: Developed through personal efforts

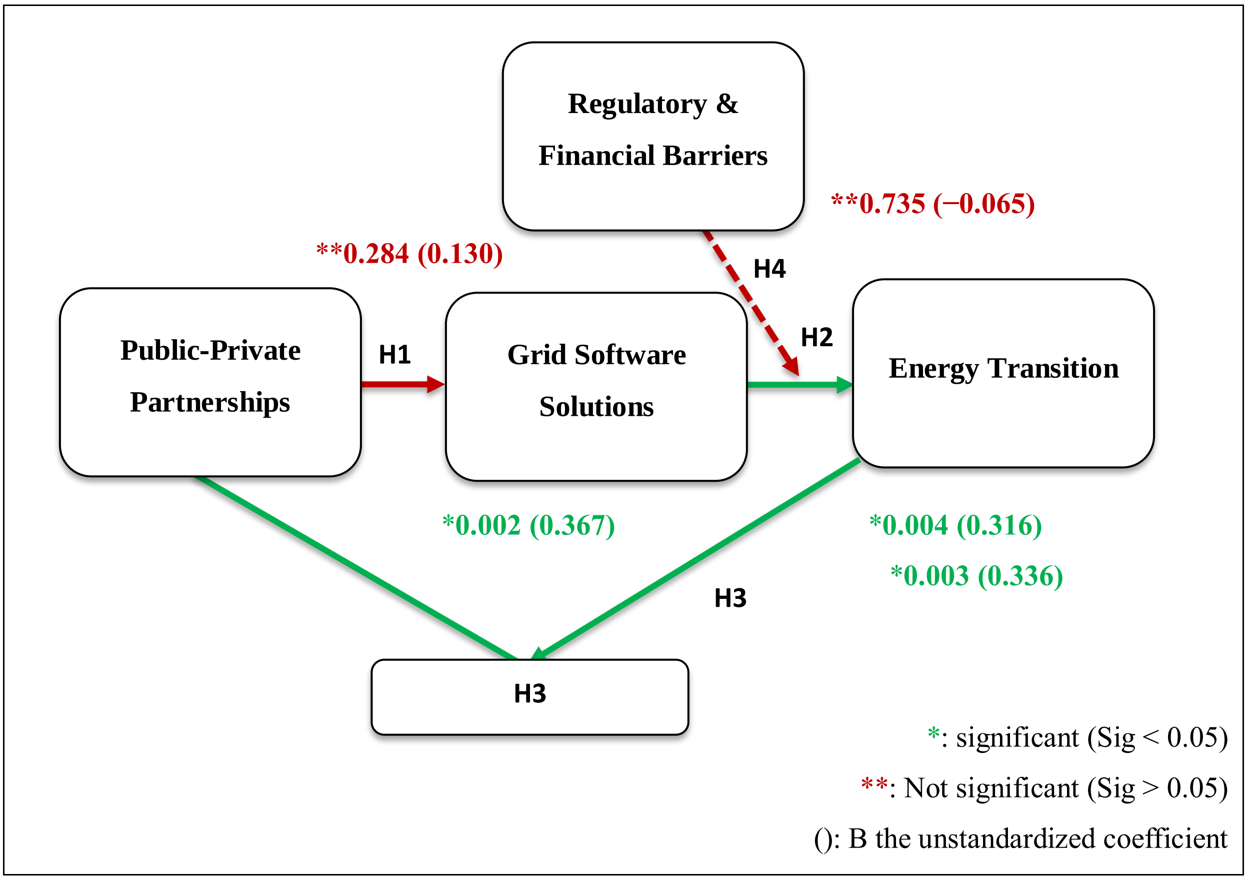
6. Validated Conceptual Model:

We used hypothesis testing to confirm or reject the initial hypotheses connecting the central variables of our study, as illustrated in the proposed conceptual model.

After conducting the hypothesis tests and obtaining the validation results, we are now able to validate our theoretical (conceptual) model by highlighting the significant relationships between the variables based on their significance levels (Sig).

The validated conceptual model is illustrated and presented in Figure 14 below:

Figure 14: Validated Conceptual Model



Source: Developed through personal efforts

II. Discussion of the Results

The statistical findings of this study provide useful insights into the role of Public-Private Partnerships (PPPs) in Algeria’s energy transition, specifically through the deployment of grid software by Siemens. While the descriptive and inferential analyses confirm the general relevance of digital tools in advancing cleaner energy systems, a more critical reflection reveals important nuances that deserve deeper examination both in terms of empirical interpretation and strategic implications.

Interpretation of Significant and Non-Significant Results

The results demonstrate that grid software significantly contributes to the efficiency of energy transition initiatives (H2) and PPPs positively influence the energy transition through grid software (H3), confirming existing literature that positions digital tools as key enablers of grid flexibility, real-time monitoring, and renewable integration (Neffati et al., 2021; Faquir et al., 2021). This finding validates the role of software-based infrastructure in achieving Algeria's renewable targets, especially in the context of aging grids and centralized control mechanisms.

Correspondingly, while PPPs may not yet be contributing directly to software development (as seen in H1), their broader contribution such as enabling infrastructure, policy alignment, and investment flows still plays a role in accelerating the energy transition. This supports findings from Othman & Khallaf (2022), Wang et al. (2022), and Taghizadeh-Hesary & Yoshino (2020), who noted that PPPs can create an ecosystem conducive to transition by aligning public goals with private expertise and capital.

However, the direct impact of PPPs on grid software development (H1) and the moderating role of regulatory and financial barriers (H4) were found to be statistically non-significant. These results invite a more critical reflection. The lack of a direct PPP effect could suggest that while collaborations exist nominally, they may be limited in scope, poorly structured, or largely symbolic in practice. This raises questions about the operational depth of such partnerships in Algeria: Are PPPs genuinely co-managed initiatives, or do they remain mostly driven by public-sector priorities with limited private-sector autonomy?

Similarly, the insignificant moderating effect of regulatory and financial barriers could stem from the homogeneity of the sample (professionals closely tied to Siemens or the energy sector), which may limit the diversity of perceived institutional challenges. Alternatively, it may suggest that while regulatory hurdles exist, they are not always explicitly linked to grid software projects, which are often implemented under pilot programs or international support frameworks that bypass conventional bureaucratic obstacles.

Strategic and Policy Implications

From a policy perspective, the findings underscore the urgent need to move beyond declarative PPP frameworks and toward functional collaborations supported by enforceable contracts, innovation incentives, and shared risk frameworks. The Algerian government could consider simplifying procurement procedures, particularly in energy-related PPPs, by revising bidding and approval processes and adopting standardized digital PPP templates to accelerate implementation timelines.

Moreover, to address the gap between strategic intent and execution, a dedicated national fund for digital infrastructure under PPP arrangements could be established. This fund would aim to co-finance projects related to smart grids, energy analytics, and cybersecurity, with participation from local and international investors. Such mechanisms would both de-risk private participation and encourage long-term engagement from technology providers like Siemens.

On a practical level, the study highlights the need for capacity-building initiatives to reinforce the human and technical infrastructure necessary to absorb and maintain advanced grid software. Public institutions and private partners should develop joint training programs targeting project managers, engineers, and decision-makers, with an emphasis on interoperability, data governance, and energy efficiency outcomes.

Recommendations

Practical Recommendations

To enhance the effectiveness of PPP-based grid software deployment in Algeria, several actionable measures are proposed:

- Establish a dedicated PPP-tech fund managed jointly by the Ministry of Energy and the private sector to co-finance smart grid projects.
- Implement modular training and certification programs on digital energy solutions for Sonelgaz and ministry staff, in collaboration with Siemens.

- Create a national digital energy lab where PPP actors can prototype, test, and evaluate new smart grid solutions before large-scale deployment.

Policy Recommendations

From a governance perspective:

Simplify and digitize PPP tendering procedures, particularly in the energy sector, to reduce project preparation time and increase transparency.

Institutionalize regulatory sandboxes for energy-tech PPPs, allowing for experimental regulation and accelerated innovation without full-scale legal reform.

Encourage local content requirements in software procurement, promoting the inclusion of Algerian SMEs in PPP energy projects.

Study Limitations

While the study provides valuable insights, certain limitations must be acknowledged. The sample is limited in size (70 participants) and scope, focused mainly on professionals already involved in energy or Siemens-led projects. This may introduce a selection bias and limit the generalizability of the results to the broader PPP ecosystem. Additionally, the reliance on self-reported data through questionnaires opens the door to social desirability bias, where respondents may overstate the effectiveness of PPPs or underreport barriers to avoid reputational risk.

Moreover, the study remains cross-sectional, offering a snapshot rather than an evolution of the impact of PPPs over time. Grid software deployment is inherently dynamic, and its benefits may only become measurable over several years, particularly when it comes to decarbonization or cost-efficiency outcomes.

Directions for Future Research

Future investigations should adopt a longitudinal design, monitoring the performance of grid software solutions across different PPP projects over time. Additionally, conducting a cost-benefit analysis of grid software implementation comparing PPP-driven vs. fully public projects would provide clearer insights into value for money and return on investment. Another promising direction would be a comparative study between Algeria and similar economies (e.g., Egypt, Morocco, South Africa) to identify replicable PPP success factors and governance models.

CONCLUSION

This study set out to examine the role of Public-Private Partnerships (PPPs) in facilitating Algeria's energy transition, with particular attention to the deployment of grid software solutions provided by Siemens. Grounded in a quantitative methodology and supported by literature on energy policy, digital infrastructure, and collaborative governance, the research explored both the direct and indirect effects of PPPs on grid modernization and decarbonization efforts.

The findings confirm that grid software significantly enhances the effectiveness of energy transition initiatives, particularly by improving real-time monitoring, system reliability, and renewable energy integration. This aligns with global research recognizing the role of smart grid technologies in creating resilient, low-carbon energy systems. Moreover, the study demonstrates that PPPs exert a positive indirect effect on the energy transition through their contribution to software deployment, even though their direct impact on software development was not statistically significant. This suggests that while PPPs play a strategic role, their operational and contractual dynamics in Algeria may require structural reform to become fully effective.

In addition, the lack of a significant moderating effect of regulatory and financial barriers raises questions about either the perceived visibility of these obstacles or the robustness of the partnerships in bypassing institutional inefficiencies. It may also point to a gap between policy discourse and on-the-ground implementation—a key issue for Algerian energy governance.

From a practical standpoint, the study highlights the importance of moving beyond symbolic partnerships to develop functionally robust PPPs with clearly defined roles, performance indicators, and long-term accountability. It also calls for the creation of dedicated financing instruments and specialized training programs to support the digitalization of Algeria's energy sector. On a policy level, simplifying procurement procedures, enhancing regulatory agility through sandboxes, and incorporating local digital actors into PPP frameworks are essential reforms to accelerate impact.

However, the study is not without limitations. The sample is relatively narrow, composed primarily of professionals affiliated with energy institutions or Siemens-related projects, which may introduce selection and desirability biases. Additionally, the cross-sectional nature of the

Analysis limits its ability to capture the long-term impact of software deployment and institutional collaboration. These factors should be addressed in future research.

To build on this study, future work could adopt a longitudinal design to assess the evolution of PPP-driven energy initiatives over time. Moreover, a cost-benefit analysis comparing PPP-based and publicly financed smart grid projects would offer practical guidance on financial efficiency. Finally, a comparative regional study between Algeria and peer countries (e.g., Morocco, Egypt, or South Africa) could yield valuable insights into scalable governance models and context-specific innovations.

In conclusion, while PPPs represent a promising pathway for digital energy transformation in Algeria, their full potential can only be unlocked through systemic reforms, operational clarity, and sustained investment in digital and human capital. This research contributes a localized, evidence-based perspective to a global conversation on how developing economies can bridge infrastructure gaps and climate goals through effective collaboration.

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APPENDICES

APPENDIX A – QUESTIONNAIRE

ENGLISH VERSION

Please help us understand how strategic collaborations and advanced grid software are driving Algeria's shift toward cleaner, smarter electricity. As a professional with Siemens, Sonelgaz, the Ministry of Energy, ALNAFT, or another partner organization, your individual insights will remain anonymous and confidential, and will be used solely for academic purposes. Your responses will directly inform best practices for Public-Private Partnerships in decarbonizing our infrastructure. This survey takes less than five minutes to complete — thank you for your valuable contribution.

Part 1: Filter (Eligibility)

Question	**Yes**	**No**
Have you ever been involved or participated in Energy Transition/Smart-Grid Project?		

If yes (continue), if no, end of the questionnaire.

Questions on the studied variables:

Using a rating scale from 1 to 5 (1 = Strongly disagree to 5 = Strongly agree), please circle the number that best represents your level of disagreement/agreement with each of the following statements:

Part 2: PPP Effectiveness on Grid Software Deployment:

Question	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
The Siemens–Sonelgaz partnership accelerates the deployment of smart grid software by providing funding and expertise.	1	2	3	4	5
The contractual arrangements in PPPs help reduce risks during the implementation of grid software projects.	1	2	3	4	5
Collaboration through PPPs ensures long-term operational efficiency of grid software.	1	2	3	4	5

Part 3: Grid Software Impact on Renewable Integration & Decarbonization

Question	Not at all	Slightly	Moderately	Effectively	Very Effectively
Advanced grid software helps stabilize voltage and frequency when renewable energy output fluctuates**.**	1	2	3	4	5

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Grid software deployment has measurably reduced CO_2 emissions in our projects.	1	2	3	4	5
Real-time analytics from grid software supports the integration of more renewable energy into the electricity mix.	1	2	3	4	5

Part 4: Grid Software Impact

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Through PPPs, Siemens has integrated grid software to help meet Algeria’s energy transition goals.	1	2	3	4	5
The Siemens–Sonelgaz partnership has strengthened infrastructure resilience through grid software solutions.	1	2	3	4	5
PPP-driven software deployment accelerated project timelines toward decarbonization.	1	2	3	4	5

Part 5: Moderating Role of Regulatory & Financial Barriers

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Regulatory complexity significantly delays grid software implementation under PPPs.	1	2	3	4	5
High investment costs limit the success of grid software projects under PPPs.	1	2	3	4	5
Financial incentives within PPPs sufficiently mitigate investment risks for grid software.	1	2	3	4	5

Part 5: Respondent Information

Information	Options
Age	☑ Under 25 ☑ 25–34 ☑ 35–44 ☑ 45–54 ☑ 55 and above
Gender	☑ Male ☑ Female
Current Role	☑ Administrative Staff ☑ Engineer/Technician ☑ Manager ☑ Consultant/Expert ☑ Other: ______
Organization/Affiliation	☑ Siemens ☑ Sonelgaz ☑ Ministry of Energy/Government Entity ☑ AFNOR/Standards Organization ☑ Private Firm ☑ Other: ______
Role in the PPP Project	☑ Core Stakeholder ☑ Technical/Standards Partner ☑ Institutional/Regulatory Support ☑ Other: ______
Sector	☑ Public ☑ Private
Education Level	☑ Senior Technician ☑ Bachelor’s ☑ Master’s ☑ Doctorate ☑ Other: ______
Primary Training Area	☑ Technical ☑ Administrative ☑ Engineering ☑ Economics/Management ☑ Environmental ☑ Other:
Years of Experience in Energy/Infrastructure	☑ <1 ☑ 1–3 ☑ 4–7 ☑ >7
Involvement in PPP Project	☑ Yes, public entity ☑ Yes, private entity ☑ No

End of Survey

Acknowledgment

FRENCH VERSION

Merci de nous aider à comprendre comment les collaborations stratégiques et les logiciels de gestion avancés du réseau électrique contribuent à la transition de l'Algérie vers une électricité plus propre et plus intelligente. En tant que professionnel(le) chez Siemens, Sonelgaz, au Ministère de l'Énergie, à l'ALNAFT ou dans une autre organisation partenaire, vos réponses individuelles resteront anonymes et confidentielles et seront utilisées uniquement à des fins académiques.Votre contribution permettra d'identifier les meilleures pratiques pour les partenariats public-privé (PPP) dans le processus de décarbonation de notre infrastructure.
Le questionnaire prend moins de cinq minutes à remplir—merci pour votre précieuse participation.

Partie 1: Filtre (Éligibilité):

Question	Oui	Non
Avez-vous déjà participé à un projet de Transition Énergétique ou de Réseau Intelligent (Smart-Grid) ?		

Si oui (continuer) si non fin du questionnaire.

Questions sur les variables étudiées:

À l'aide d'une échelle de notation de 1 à 5 (1= pas du tout d'accord à 5 = Tout à fait d'accord), veuillez encercler le chiffre qui indique votre niveau de désaccord/d'accord par rapport à chacune des expressions suivantes :

Partie 2: Efficacité des partenariats public-privé (PPP) sur le déploiement des logiciels de gestion de réseau électrique

Question	Pas du tout d'accord	Pas d'accord	Neutre	D'accord	Tout à fait d'accord
Le partenariat Siemens–Sonelgaz accélère le déploiement des logiciels de réseau intelligent grâce au financement et à l'expertise.	1	2	3	4	5

Les accords contractuels dans les PPP contribuent à réduire les risques lors de l'implémentation des projets de logiciels de réseau.	1	2	3	4	5
La collaboration via les PPP garantit l'efficacité opérationnelle à long terme des logiciels de réseau.	1	2	3	4	5

Partie 3: Impact des logiciels de gestion de réseau sur l'intégration des énergies renouvelables et la décarbonation

Question	**Pas du tout**	**Légèrement**	**Modérément**	**Efficacement**	**Très efficacement**
Les logiciels de réseau avancés stabilisent efficacement la tension et la fréquence face aux fluctuations des énergies renouvelables.	1	2	3	4	5

Question	**Pas du tout d’accord**	**Pas d'accord**	**Neutre**	**D'accord**	**Tout à fait d'accord**
Le déploiement des logiciels de réseau a permis de réduire de manière mesurable les émissions de CO_2 dans nos projets.	1	2	3	4	5
L'analyse en temps réel fournie par les logiciels de réseau facilite l'intégration d'une plus grande part d'énergies renouvelables dans le mix électrique.	1	2	3	4	5

Partie 4: L’impact des logiciels de réseau

Question	**Pas du tout d’accord**	**Pas d'accord**	**Neutre**	**D'accord**	**Tout à fait d'accord**
Grâce aux PPP, Siemens a intégré des logiciels de réseau pour contribuer aux objectifs de transition énergétique de l'Algérie.	1	2	3	4	5
Le partenariat Siemens–Sonelgaz a renforcé la résilience des infrastructures grâce aux solutions de logiciels de réseau.	1	2	3	4	5
Le déploiement de logiciels sous PPP a accéléré les délais des projets de décarbonation.	1	2	3	4	5

Partie 5: Rôle modérateur des barrières réglementaires et financières

Question	**Pas du tout d’accord**	**Pas d'accord**	**Neutre**	**D'accord**	**Tout à fait d'accord**
La complexité réglementaire retarde significativement la mise en œuvre des logiciels de réseau dans le cadre des PPP.	1	2	3	4	5
Les coûts d'investissement élevés limitent le succès des projets de logiciels de réseau sous PPP.	1	2	3	4	5
Les incitations financières dans les PPP suffisent-elles à atténuer les risques d'investissement pour les logiciels de réseau.	1	2	3	4	5

Partie 6: Fiche Signalétique

Informations	Options
Âge	☑ Moins de 25 ans ☑ 25–34 ans ☑ 35–44 ans ☑ 45–54 ans ☑ 55 ans et plus
Genre	☑ Homme ☑ Femme
Fonction actuelle	☑ Personnel administratif ☑ Ingénieur/Technicien ☑ Responsable ☑ Consultant/Expert ☑ Autre : ____
Organisation/Affiliation	☑ Siemens ☑ Sonelgaz ☑ Ministère de l'Énergie/Entité gouvernementale ☑ AFNOR/Organisme de normalisation ☑ Entreprise privée ☑ Autre :
Rôle dans le projet de partenariat public-privé (PPP)	☑ Partie prenante principale ☑ Partenaire technique/de normalisation ☑ Soutien institutionnel/réglementaire
Secteur	☑ Autre:
Niveau d'études	☑ Public ☑ Privé
Domaine de formation principal	☑ Technicien supérieur ☑ Licence ☑ Master ☑ Doctorat ☑ Autre :
Années d'expérience dans l'énergie/l'infrastructure	☑ Technique ☑ Administratif ☑ Ingénierie ☑ Économie/Gestion ☑ Environnement ☑ Autre :
Implication dans un projet de partenariat public-privé	☑ <1 ☑ 1–3 ☑ 4–7 ☑ >7

Fin du sondage

Remerciement