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# Toward a Smart City: The challenges of energy-autonomous Neighborhoods in CHLEF City – Case study : “El-Hassania Neighborhood” –

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*Fedwa* 



## *Dedication*

With profound gratitude to ALLAH, I dedicate this work to the pillars of my life:

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# INTRODUCTORY CHAPTER

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## General Introduction:

In our fast-paced world, where urbanization and technology are seamlessly intertwined, the concept of smart cities has emerged as a beacon of hope for tackling the complex issues that arise from modern urban living. The key objective of this evolution is to establish urban landscapes that not only function efficiently and sustainably but also prioritize the needs and welfare of their residents.

The European Commission defines a smart city as one that **"uses digital technologies to enhance performance well beyond the basic infrastructure provision, to improve the welfare of citizens, grow the economy sustainably, and respond to a range of urban challenges."**

As we imagine the cities of tomorrow, an exciting new frontier emerges energy-autonomous neighbourhoods. This concept embodies a dedication to sustainability, resilience, and self-sufficiency, and it aims to create urban spaces that not only consume energy but generate and manage it as well. Energy-autonomous quarters represent a departure from traditional energy models, embracing innovative solutions that incorporate renewable sources, cutting-edge technologies, and intelligent infrastructure. This shift is not only a technological challenge, but also a holistic transformation that impacts urban planning, community dynamics, and environmental consciousness.

In the specific context of Algeria, a country marked by both rapid urbanization and a growing commitment to renewable energy, the journey towards smart cities and energy-autonomous quarters takes on unique dimensions and imperatives.

Algeria occupies a unique position where its diverse landscapes and growing urban centers intersect with the need to balance tradition and modernity. With the expansion of Algerian cities comes a rising energy demand, creating a pressing need for innovative solutions to ensure sustainable power sources. As such, the idea of energy-autonomous quarters offers a promising way to mitigate the environmental impact of urbanization while promoting resilience and self-sufficiency.

The Algerian landscape is a fascinating blend of old and new urban developments, with historic cities coexisting alongside modern ones. Algeria is committed to harnessing its vast solar and wind resources, making renewable energy integration a

top priority. The Renewable Energy and Energy Efficiency Program is just one of the initiatives aimed at promoting cleaner and more sustainable energy practices. Against this backdrop, energy-autonomous quarters are emerging as a smart strategy to decentralize energy production, reducing dependence on centralized grids and bolstering the resilience of urban communities.

### **Problem statement:**

The world is experiencing unprecedented urbanization, with more than half of the global population living in cities. This rapid urban growth has led to a surge in energy demand, posing significant challenges to the sustainability of urban development. In response, the concept of smart cities and energy-autonomous quarters has emerged as a promising solution to address the energy demands of urbanization while promoting environmental sustainability, community resilience, and holistic urban development. However, the integration of energy-autonomous quarters presents a complex set of challenges that must be addressed to realize the full potential of this concept.

Within the specific context of Algeria, a nation undergoing significant urban transformation, the need to develop energy-autonomous quarters that can effectively address the escalating energy demands while fostering environmental sustainability and community resilience becomes increasingly urgent.

The journey towards a sustainable and energy-efficient future in Algeria demands a significant move towards smart cities and energy-autonomous quarters. Chlef is currently being studied as a prime example to unravel the unique challenges and opportunities that existing urban centres face. The transformation of quarters plays a critical role in this transition, allowing for a systematic and gradual approach to building smart cities. By examining quarters as the fundamental building blocks.

El-Hassania quarter in Chlef, Algeria, offers a unique opportunity to explore the challenges and opportunities associated with the integration of energy-autonomous quarters in a diverse urban setting. By examining the current energy infrastructure, consumption patterns, and community dynamics within the El-Hassania quarter, this

research aims to identify barriers to and enablers of the successful implementation of energy-autonomous quarters.

Additionally, the study seeks to propose actionable strategies and frameworks that can optimize the integration of energy-autonomous quarters, thereby addressing the burgeoning energy demands of rapid urbanization while catalyzing a paradigm shift towards environmental sustainability, community resilience, and holistic urban development.

**Preliminary questions:**

- What are the main obstacles currently faced by urban areas in Algeria, particularly in Chlef, in achieving energy autonomy?
- How can innovative technologies be practically implemented in El-Hassania quarter and similar settings to enhance energy efficiency and community resilience?

The central research question that guides this thesis is:

In the pursuit of energy autonomy within smart cities, how can the seamless integration of innovative strategies and cutting-edge technologies transcend technical, economic, and social barriers to not only meet the surging energy demands of rapid urbanization but also foster environmental sustainability, community resilience, and holistic urban development, thereby redefining the paradigm of sustainable urban living in Algeria and globally?

**Hypothesis:**

To tackle the questions posed in the problem statement and guide the research in a focused direction, we suggest the following hypotheses:

- Implementing innovative technologies and strategies can help overcome obstacles to energy autonomy in urban areas of Algeria, such as Chlef, by addressing technical, economic, and social challenges.
- The practical implementation of innovative technologies, particularly in quarters like El-Hassania, will lead to enhanced energy efficiency, increased community

resilience, and improved environmental sustainability, thus redefining sustainable urban living paradigms in Algeria and globally.

- The main obstacles faced by urban areas in Algeria, including Chlef, in achieving energy autonomy primarily stem from infrastructural deficiencies and regulatory constraints rather than technological limitations

### **The objectives of the research:**

- ✓ Identify obstacles to achieving energy autonomy in Chlef's El-Hassania quarter and similar urban areas in Algeria.
- ✓ Evaluate practical implementation strategies for innovative technologies to enhance energy efficiency and community resilience in El-Hassania quarter.
- ✓ Develop actionable strategies and frameworks to optimize the integration of energy-autonomous quarters, promoting sustainable urban living in Algeria.

### **Choice motivation:**

- El-Hassania Quarter and its unique blend of opportunities and challenges. El-Hassania is experiencing rapid urbanization, which presents both a pressing need and a fertile ground for innovative solutions in energy management.
- The district's existing infrastructure and community dynamics offer a practical context to explore and implement energy-autonomous strategies. By focusing on El-Hassania, I aim to address the urgent demand for sustainable urban development and showcase how energy autonomy can mitigate the impacts of rapid urban growth, ultimately contributing to the broader goal of transforming Chlef into a resilient and smart city.

### **Methodology and research tools:**

In conducting this research on transforming the El-Hassania Quarter into an energy-autonomous smart district, a mixed-methods approach will be utilized. This methodology combines both qualitative and quantitative

research methods to provide a comprehensive understanding of the challenges and opportunities involved.

## 1. Qualitative Research

**Objective:** To understand the perceptions, attitudes, and insights of the community and stakeholders regarding the transition to an energy-autonomous district.

**Methods:**

**Interviews:** Conduct in-depth interviews with key stakeholders, including local government officials, community leaders, and residents. These interviews will help gather detailed qualitative data on their views and experiences.

**Content Analysis:** Review and analyze existing documents, reports, and policies related to urban development and smart city initiatives in Chlef and similar contexts.

**Tools:**

**Interview Guides:** Structured and semi-structured interview guides tailored to different stakeholder groups.

## 2. Quantitative Research

**Objective:** To quantify the potential impact, feasibility, and technical requirements for transforming the El-Hassania Quarter into an energy-autonomous district.

**Methods:**

**Surveys:** Distribute structured questionnaires to a larger sample of residents to gather quantitative data on their energy usage, willingness to adopt new technologies, and the satisfaction with current infrastructure. **Data Analysis:** Utilize statistical methods to analyze survey responses and identify key trends and correlations.

**Tools:**

**Questionnaires:** Well-designed survey instruments with a mix of closed and open-ended questions.

**SPSS:** Statistical software for analyzing survey data, including univariate, bivariate, and multivariate analyses.

**Excel:** For data entry, preliminary analysis, and visualization of quantitative data.

### 3. Technical and Spatial Analysis

**Objective:** To evaluate the technical feasibility and spatial requirements for implementing energy solutions in the El-Hassania Quarter.

**Methods:**

**Geographical Information System (GIS) Analysis:** Mapping and spatial analysis to identify suitable locations for solar panels, biogas plants, and other infrastructure.

**Energy Modeling:** Use energy simulation tools to model the potential energy generation and consumption patterns in the district.

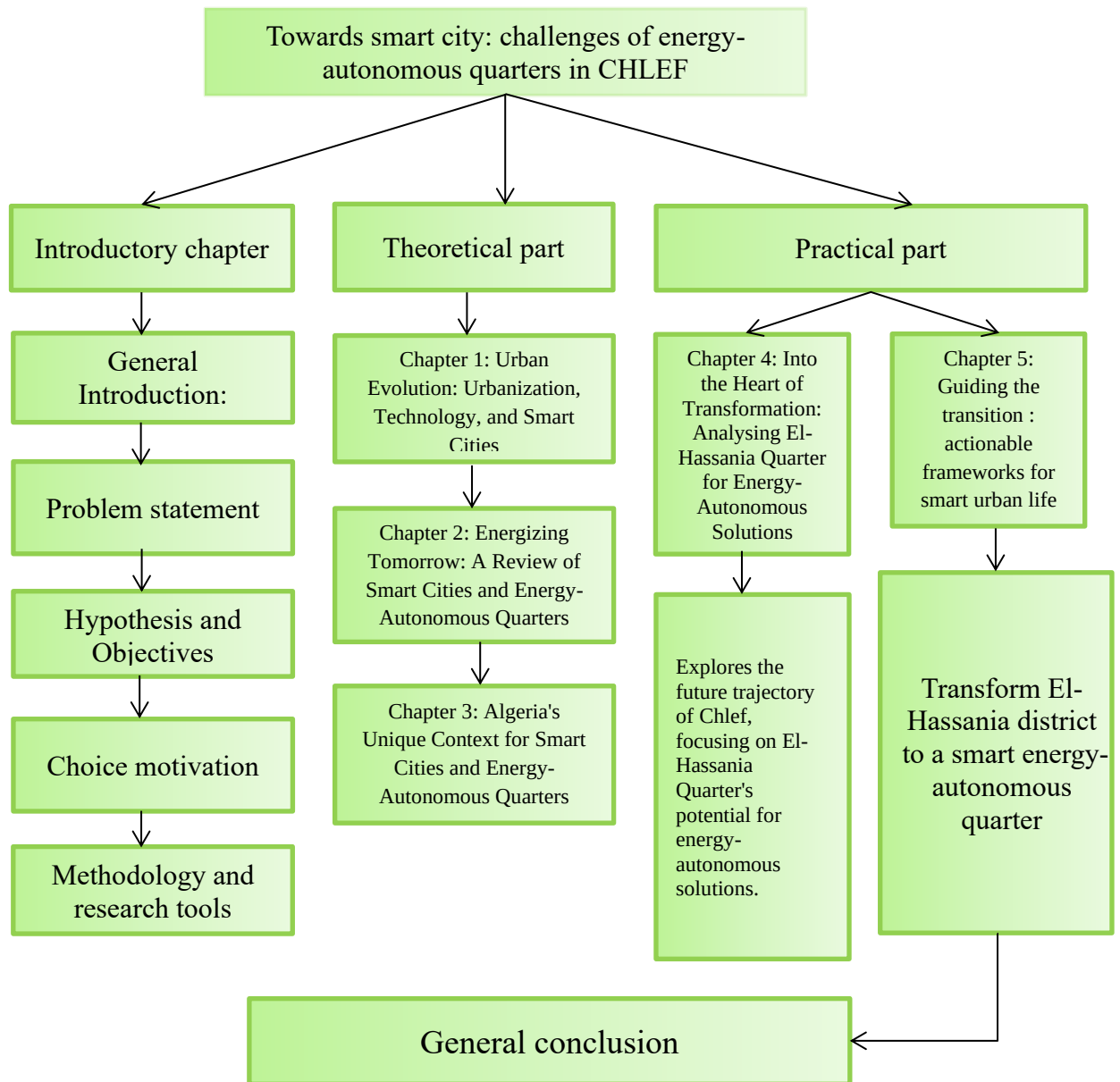
**Tools:**

**GIS Software:** ArcGIS for spatial data analysis and visualization.

**SAM (System Advisor Model):** To model the performance and financial viability of solar photovoltaic systems and other renewable energy solutions.

**Flowchart:**

The research is structured as follows:





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## **CHAPTER I :**

# **Urban Evolution: Urbanization, Technology, and Smart Cities**

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1. The Dynamics of Urbanization
2. The Role of Technology in Urban Transformation
3. Smart Cities: Conceptual Framework and Evolutionary Perspectives
4. Digital Urbanism: Exploring the Nexus of Technology and Urban Development
5. Conclusion

**Introduction:**

Urbanization is a dynamic and multifaceted process that has played a pivotal role in shaping the growth and development of cities throughout history. From the ancient settlements of Mesopotamia to the modern metropolises of today, the evolution of urban areas has been influenced by a myriad of social, economic, and environmental factors.

This chapter delves into the intricate dynamics of urbanization, exploring how cities have transformed, adapted, and thrived in response to changing societal needs and global challenges.

Urbanization encompasses a complex interplay of factors that drive the evolution of cities. By examining the historical perspectives on urban growth, we can trace the origins of urbanization back to ancient civilizations such as Sumer, Egypt, Greece, and Rome. These early urban centers served as hubs for economic, social, and cultural exchange, laying the groundwork for the development of more complex urban forms.

Throughout history, urbanization has experienced ebbs and flows, influenced by factors such as invasions, plagues, and technological advancements. The Industrial Revolution of the 18th and 19th centuries, for example, revolutionized urbanization patterns through the introduction of steam power and mass production techniques.

This era marked a significant shift in urban development, leading to the rapid expansion of cities and the emergence of industrial hubs. In recent years, technological innovations have played a crucial role in shaping the landscape of urban areas.

The rise of smart cities, characterized by the integration of digital technologies and data-driven solutions, has transformed how cities are planned, managed, and experienced. From smart infrastructure and IoT devices to data analytics and AI applications, technology has revolutionized urban development practices, making cities more efficient, sustainable, and responsive to the needs of their residents. By embracing technology, sustainability, and citizen engagement, cities can pave the way for a smarter, more livable future.

This chapter will explore the impact of technology on urban evolution, highlighting the opportunities and challenges that come with building vibrant, sustainable cities for generations to come.

Through a comprehensive examination of the historical roots, technological advancements, and the rise of smart cities in the urban landscape, this chapter aims to provide insights into the past, present, and future of urbanization. By understanding the dynamics of urbanization and the role of technology in shaping cities, we can work towards creating inclusive, resilient, and sustainable urban environments that enhance the quality of life for all residents.

## 1. The Dynamics of Urbanization:

Urbanization is a complex and multifaceted process that has shaped the growth and development of cities worldwide. From ancient settlements to modern metropolises, the dynamics of urbanization encompass social, economic, and environmental factors that influence how cities evolve over time. By examining the patterns, trends, and drivers of urbanization, we gain a deeper understanding of how cities transform, adapt, and thrive in response to changing societal needs and global challenges.

### 1.1 Historical Perspectives on Urban Growth:

Urbanization has a long history dating back to ancient civilizations, where the concentration of people in urban centers facilitated economic, social, and cultural exchange. The earliest urban settlements, such as Mesopotamia's Sumerian cities of Ur and Uruk, emerged around 3500 BCE as agricultural societies transitioned to more complex urban forms (Childe, 1950). These cities served as administrative, religious, and economic hubs, laying the foundation for future urban development.

Ancient civilizations like Egypt, Greece, and Rome further advanced urbanization through monumental architecture, sophisticated infrastructure, and centralized governance structures. The development of aqueducts, roads, and public buildings facilitated urban growth and societal complexity (Morris, 1999).

During the Middle Ages, urbanization in Europe experienced a decline due to factors such as invasions, plagues, and feudalism. However, the Renaissance and later periods saw a resurgence of urban growth, marked by the expansion of trade, commerce, and industry in cities like Venice, Florence, and London.

The Industrial Revolution of the 18th and 19th centuries brought about profound changes in urbanization patterns. The invention of steam power, mechanization, and factory production led to the rapid growth of industrial cities like Manchester, Birmingham, and Chicago (Clark, 1987). This period witnessed mass migrations from rural areas to urban centers in search of employment opportunities, resulting in overcrowded living conditions and social upheaval.



*Figure 1 Dubai urban growth*

Source: [www.sciencedirect.com](http://www.sciencedirect.com)

### **1.2 Contemporary Trends in Urbanization:**

The 19th and 20th centuries marked a significant acceleration in urbanization, driven by industrialization, population growth, and rural-to-urban migration. The Industrial Revolution transformed the socio-economic landscape, leading to the rise of industrial cities characterized by factory production, mass transportation systems, and urban sprawl (Clark, 1987). Cities like Manchester, Birmingham, and Pittsburgh became epicenters of industrial activity, attracting migrants from rural areas in search of employment opportunities (Hobsbawm, 1968).

The 20th century witnessed unprecedented urban growth, fueled by factors such as demographic shifts, technological advancements, and globalization. The process of suburbanization emerged in Western countries, driven by rising affluence, automobile ownership, and government policies promoting homeownership (Jackson, 1985). Suburban developments, characterized by single-family homes, shopping malls, and decentralized infrastructure, reshaped the urban landscape and contributed to urban sprawl (Fishman, 1987).

In the latter half of the 20th century, urbanization became a global phenomenon, with rapid population growth and urban expansion occurring in developing regions. The phenomenon of "megacities," defined as urban agglomerations with populations exceeding ten million inhabitants, became increasingly common in regions such as Asia, Africa, and Latin America (Davis, 2006). Cities like Tokyo, Mumbai, and Lagos exemplify the challenges and opportunities associated with rapid urbanization, including infrastructure deficits, environmental degradation, and socio-economic disparities (Satterthwaite, 2007).



**Figure 2 Tokyo the largest mega city in the world**

Source: [Largest Cities by Population 2024 \(worldpopulationreview.com\)](https://worldpopulationreview.com/largest-cities/)

### **1.3 Challenges and Opportunities of Urban Development:**

Contemporary urbanization presents a myriad of challenges and opportunities for policymakers, planners, and residents alike. One of the primary challenges is the strain on urban infrastructure and services, as rapid population growth outpaces the expansion of transportation, housing, and utilities (Angel et al., 2010). Traffic congestion, inadequate housing, and limited access to clean water and sanitation are common issues faced by rapidly growing cities (UN-Habitat, 2016).

Furthermore, urbanization contributes to environmental degradation through increased pollution, habitat destruction, and resource consumption (Grimm et al., 2008). The concentration of populations and economic activities in cities exacerbates carbon emissions, air and water pollution, and deforestation, leading to adverse impacts on public health and ecosystem services (Seto et al., 2011).

However, urbanization also presents opportunities for innovation, economic growth, and sustainable development. The concept of "smart cities" leverages technology and data-driven solutions to improve urban efficiency, resilience, and quality of life (Caragliu et al., 2009). Initiatives such as smart grid systems, intelligent transportation networks, and digital governance platforms demonstrate the potential for addressing urban challenges while fostering economic competitiveness and social inclusion (Hollands, 2008).

It is paramount to comprehend the intricate interplay of historical legacies, contemporary trends, and future aspirations that drive urbanization dynamics. Without this understanding, we cannot create sustainable, inclusive, and resilient cities that cater to the needs of future generations.

## **2. The Role of Technology in Urban Transformation:**

Technology plays a crucial role in shaping the trajectory of urban development, influencing various aspects of urban life, from physical infrastructure to governance structures.

## 2.1 Technological Advancements Shaping Urban Spaces:

Technological advancements have significantly influenced the design and construction of urban spaces, leading to the emergence of innovative architectural and urban planning practices. The integration of digital tools such as Building Information Modeling (BIM) has revolutionized the architectural design process, allowing architects and urban planners to create highly complex and sustainable structures (Picon, 2010). BIM enables the visualization of building designs in three dimensions, facilitating collaboration among stakeholders and optimizing building performance through simulation and analysis (Kiviniemi et al., 2013).

Furthermore, advancements in materials science and construction techniques have enabled the development of high-performance buildings that are energy-efficient, environmentally friendly, and resilient to natural hazards (Fernández-Solís et al., 2016). For example, the use of sustainable materials such as cross-laminated timber (CLT) and recycled steel reduces the environmental impact of construction while improving structural integrity and thermal insulation (Mahdavi et al., 2015).

Moreover, digital fabrication technologies such as 3D printing and robotic construction have the potential to revolutionize the construction industry by enabling the rapid and cost-effective fabrication of complex architectural elements and building components (Buswell et al., 2007). 3D printing, also known as additive manufacturing, allows architects and engineers to create custom-designed building elements with minimal material waste and construction time (Le et al., 2018). Robotic construction, on the other hand, utilizes advanced robotics and automation technologies to assemble prefabricated building components on-site, increasing construction efficiency and precision (Friedman et al., 2013).

## 2.2 Impacts of Technology on Urban Infrastructure:

Technology has transformed the way urban infrastructure systems are designed, operated, and maintained, leading to more efficient, resilient, and sustainable cities. The integration of digital sensors, communication networks, and data analytics has enabled the development of smart infrastructure systems that monitor and optimize various urban functions in real time (Chen et al., 2017). For example, smart transportation systems leverage real-time data from sensors embedded in roads, vehicles, and public transit systems to improve traffic flow, reduce congestion, and enhance road safety (Mahmassani et al., 2016).

Furthermore, advancements in renewable energy technologies have revolutionized urban energy infrastructure, enabling the transition towards cleaner and more sustainable energy sources. Smart grid systems integrate renewable energy sources such as solar, wind, and geothermal power into the urban energy grid, allowing for decentralized energy generation and distribution (Farhangi, 2010). Smart grids also enable demand response programs that incentivize consumers to adjust their electricity consumption patterns based on fluctuations in energy supply and demand, leading to more efficient use of energy resources (Albadi & El-Saadany, 2012).

Moreover, technology plays a crucial role in enhancing the resilience of urban infrastructure systems to natural disasters and climate change. The use of predictive analytics and machine learning algorithms enables early warning systems for extreme weather events such as hurricanes, floods, and wildfires, allowing urban planners and emergency responders to mitigate their impacts and improve disaster preparedness (Jiang et al., 2018)

### **2.3 Digital Innovations in Urban Governance:**

Technology has also revolutionized urban governance, empowering governments and citizens to collaborate in decision-making and service delivery. Digital platforms and mobile applications facilitate participatory planning processes, allowing residents to provide feedback on urban projects and policies (Bryson et al., 2014). Open data initiatives promote transparency and accountability by making government data accessible to the public for analysis and visualization (Kitchin, 2014).

Furthermore, digital governance tools enable more efficient and responsive public service delivery. E-government services streamline administrative processes such as permit applications, tax payments, and public inquiries, reducing bureaucracy and enhancing citizen satisfaction (Moon, 2002). Additionally, social media platforms serve as channels for communication and engagement between government agencies and residents, fostering civic dialogue and community empowerment (Bonsón et al., 2012).

The current technological advancements are having a significant impact on urban landscapes, infrastructure, and governance systems. These advancements offer novel prospects for sustainable and inclusive urban development. By harnessing technology, we can create more efficient and eco-friendly cities, improve transportation networks, and enhance the quality of life for urban residents. Additionally, technology can help us to address issues such as poverty, inequality, and social exclusion, making our cities more inclusive and equitable.

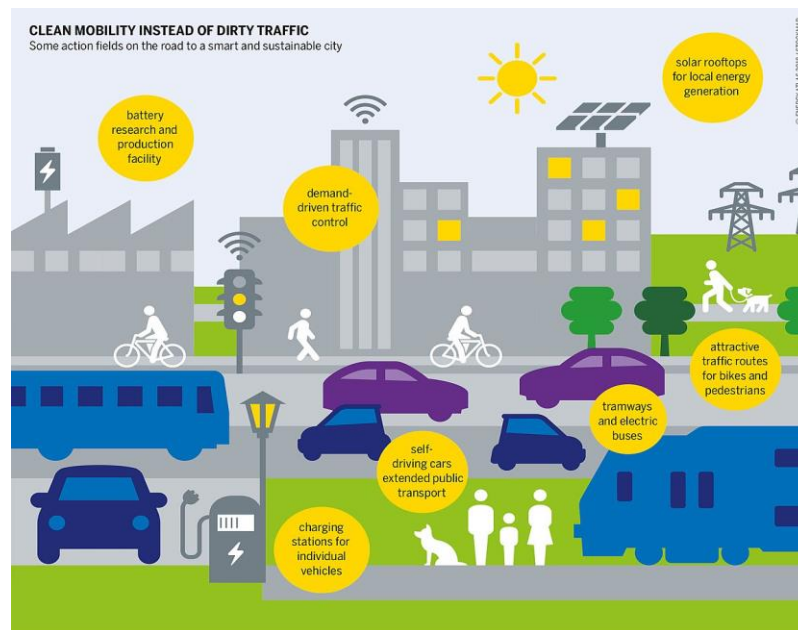


*Figure 3 Digital Innovations in Urban Governance*

Source: [www.hlp.city/smart-governance](http://www.hlp.city/smart-governance)

### 3. Smart Cities: Conceptual Framework and Evolutionary Perspectives:

Smart cities embody a new approach to urban development, where technology enhances urban efficiency, sustainability, and quality of life. By exploring the conceptual framework and evolutionary perspectives, we uncover how cities transition towards smart urban centers through technological advancements, socio-economic shifts, and innovative governance models.

### 3.1 Defining Smart Cities: Concepts of Smart Cities:

Smart cities leverage information and communication technologies (ICTs) to enhance the efficiency, sustainability, and livability of urban environments (Caragliu et al., 2009). These technologies enable cities to collect, analyze, and utilize data to optimize infrastructure, services, and governance processes (Hollands, 2008). Key components of smart cities include:

- **Digital Infrastructure:** Smart cities are equipped with robust digital infrastructure, including high-speed internet connectivity, sensor networks, and data centers, enabling the collection and exchange of real-time data (Komninos, 2002).
- **Data-driven Decision-making:** Smart cities utilize data analytics and predictive modeling to inform decision-making across various domains, including transportation, energy, and public safety (Albino et al., 2015).
- **Citizen Engagement:** Smart cities prioritize citizen engagement and participation through digital platforms, mobile applications, and participatory planning processes (Nam & Pardo, 2011).

- **Sustainability:** Smart cities embrace sustainable practices by integrating environmental considerations into urban planning, infrastructure design, and resource management (Harrison & Donnelly, 2011).



Figure 4 Defining Smart Cities Concepts of Smart Cities

Source: [www.hlp.city/smart-governance](http://www.hlp.city/smart-governance)

### 3.2 Evolutionary Trajectories: From Traditional Cities to Smart Urban Centers:

The evolution of cities from traditional urban centers to smart urban centers represents a transformative journey driven by technological advancements, changing socio-economic dynamics, and evolving governance paradigms. This section explores the evolutionary trajectories that have shaped the transition towards smart cities.

#### 3.2.1 Traditional Cities: Historical Foundations:

Traditional cities, also known as pre-modern or historical cities, have been the cradle of human civilization for millennia. These cities emerged organically over time, shaped by a combination of geographical factors, cultural influences, and economic activities. Examples of traditional cities include ancient settlements like Rome, Athens, and Cairo, which served as centers of governance, commerce, and culture in their respective regions.

Traditional cities were characterized by dense, mixed-use urban cores, where residential, commercial, and industrial activities coexisted within close proximity. Streets were narrow and winding, reflecting the organic growth of the city over time. Public spaces such as



Figure 5 Traditional Cities Historical Foundations

Source: <https://whc.unesco.org/en/list/502>

marketplaces, plazas, and religious centers played a central role in social and civic life, fostering community interaction and cultural exchange (Jacobs, 1961).

### **3.2.2 Industrialization and Urban Growth:**

The Industrial Revolution, which began in the late 18th century, marked a significant turning point in the evolution of cities. Rapid technological advancements in manufacturing, transportation, and communication transformed urban economies and landscapes. Industrial cities emerged as centers of mass production, powered by steam engines and later, electricity.

Cities like Manchester, Birmingham, and Pittsburgh became emblematic of industrial urbanization, characterized by large factories, crowded tenements, and polluted air and waterways (Clark, 1987). The influx of rural migrants seeking employment in factories led to rapid population growth and the expansion of urban boundaries. Industrialization also spurred the development of transportation infrastructure, including railways and canals, facilitating the movement of goods and people across vast distances (Fishman, 1987).

### **3.2.3 Modernization and Technological Innovation:**

The 20th century witnessed further urbanization and modernization, fueled by technological innovations and economic development. The widespread adoption of the automobile revolutionized urban transportation and mobility, leading to the proliferation of suburbs and the decentralization of urban areas (Jackson, 1985). The expansion of highway networks and the construction of interstate highways facilitated suburban growth and the rise of car-dependent lifestyles.

Technological advancements in telecommunications, electrification, and sanitation improved living standards and transformed urban infrastructure. The introduction of electricity enabled the widespread adoption of electric lighting, appliances, and machinery, revolutionizing urban households and industries. Meanwhile, improvements in sanitation and public health measures reduced the prevalence of infectious diseases and improved overall quality of life (Fishman, 1987).

### 3.2.4 The Emergence of Smart Cities:

The concept of smart cities emerged in response to the challenges and opportunities presented by rapid urbanization, environmental degradation, and resource constraints in the 21st century. Smart cities represent a holistic approach to urban governance and development, leveraging Information and Communication Technologies (ICTs) to address urban challenges and enhance quality of life (Harrison & Donnelly, 2011).

#### Key drivers of the transition towards smart urban centers include:

- ❖ **Technological Innovations:** Advances in digital technologies, such as the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data analytics, have enabled the integration of ICTs into urban infrastructure and services, creating opportunities for data-driven decision-making and resource optimization (Caragliu et al., 2009).
- ❖ **Sustainable Development:** Growing concerns about environmental sustainability and climate change have prompted cities to adopt smart solutions that promote energy efficiency, renewable energy, waste management, and green infrastructure (Albino et al., 2015).
- ❖ **Citizen Engagement:** The rise of digital platforms and social media has empowered citizens to actively participate in urban governance, providing feedback, reporting issues, and collaborating with government agencies and other stakeholders in co-creating solutions for urban challenges (Nam & Pardo, 2011).
- ❖ **Globalization and Urban Competitiveness:** Cities are increasingly competing on a global stage for investment, talent, and resources. Smart city initiatives, with their focus on innovation, entrepreneurship, and quality of life, have become key drivers of urban competitiveness and economic development (Bettencourt et al., 2007).

The transition from conventional cities to smart urban centers is a multifaceted and ever-changing process that is influenced by historical legacies, technological advancements, socio-economic factors, and evolving governance models. Smart cities embody the desire of urban areas to become more sustainable, inclusive, and resilient in the face of challenges of the 21st century.

### 3.3 Criteria for Assessing Smart Cities:

Assessing the "smartness" of cities requires a comprehensive evaluation of various dimensions, ranging from technological readiness to governance effectiveness and quality of life indicators. Common criteria for assessing smart cities include:

- ❖ **Technological Infrastructure:** This criterion evaluates the availability, quality, and accessibility of ICT infrastructure, including broadband connectivity, sensor networks, and digital services. It assesses the extent to which cities have invested in digital technologies to enable data-driven decision-making and improve service delivery (Hollands, 2008).
- ❖ **Innovation Ecosystem:** Smart cities foster innovation and entrepreneurship by creating conducive environments for collaboration between industry, academia, and government. This criterion examines the presence of innovation hubs, research

institutions, and startup incubators that support technological innovation and knowledge exchange (Caragliu et al., 2009).

- ❖ **Governance and Policy:** Effective governance and supportive policy frameworks are essential for driving smart city initiatives. This criterion evaluates the presence of transparent, participatory, and accountable governance structures that facilitate the adoption and implementation of smart city projects. It also assesses the alignment of urban policies with the principles of sustainability, equity, and inclusivity (Nam & Pardo, 2011).
- ❖ **Environmental Sustainability:** Smart cities prioritize environmental sustainability by implementing initiatives to reduce carbon emissions, improve air and water quality, and enhance natural resource management. This criterion examines the city's efforts to promote sustainable transportation, energy efficiency, waste reduction, and green space preservation (Albino et al., 2015).
- ❖ **Quality of Life:** At the heart of smart city initiatives is the goal of enhancing the quality of life for residents. This criterion assesses indicators related to healthcare, education, housing, transportation, safety, and cultural amenities. It evaluates the extent to which smart city interventions contribute to improving overall well-being and social inclusion (Harrison & Donnelly, 2011).



Figure 6 Criteria for Assessing Smart Cities

Source: [www.edenias.in](http://www.edenias.in)

### **3.4 Challenges and Opportunities in Implementing Smart City Strategies:**

As urban areas worldwide seek to become more efficient, sustainable, and livable, smart city strategies emerge as pivotal frameworks for future development. These strategies involve integrating advanced technologies to enhance urban infrastructure, services, and overall quality of life. However, the path to becoming a smart city is fraught with numerous challenges and opportunities that need to be carefully navigated to achieve desired outcomes.

#### **3.4.1 Challenges in Implementing Smart City Strategies:**

Implementing smart city strategies involves overcoming a variety of complex challenges that span technological, social, financial, and regulatory domains. These challenges must be addressed to ensure the successful adoption and sustainability of smart city initiatives.

##### **3.4.1.1 Technological Integration:**

The seamless integration of diverse technological solutions across urban systems is a fundamental challenge in smart city implementation. It involves ensuring interoperability between different platforms, systems, and devices to enable efficient data exchange and communication. For example, integrating smart traffic management systems with public transportation networks and emergency response systems requires standardized protocols and interfaces to facilitate real-time information sharing (Caragliu et al., 2009).

##### **3.4.1.2 Data Privacy and Security:**

Smart city initiatives rely heavily on the collection, analysis, and utilization of vast amounts of data from various sources, including sensors, IoT devices, and citizen interactions. Ensuring the privacy and security of this data is paramount to building trust among residents and safeguarding against potential cyber threats and privacy breaches. Striking a balance between data-driven innovation and individual privacy rights requires robust data protection policies, secure data management practices, and transparent governance mechanisms (Giffinger et al., 2007).

##### **3.4.1.3 Digital Divide:**

The digital divide, characterized by disparities in access to and usage of digital technologies, poses a significant challenge in smart city implementation. Marginalized communities, including low-income households, elderly populations, and rural areas, may lack access to affordable internet connectivity, digital devices, and technological literacy. Bridging this gap through inclusive policies, targeted infrastructure investments, and digital skills training programs is essential to ensure equitable access to smart city benefits and opportunities (Hollands, 2008).

##### **3.4.1.4 Financial Sustainability:**

Implementing smart city projects requires significant financial investment in technology deployment, infrastructure upgrades, and capacity building. Securing long-term funding and establishing sustainable financing mechanisms to support ongoing operations and maintenance is a critical challenge for city governments and stakeholders. Exploring innovative financing models, such as public-private partnerships, value capture mechanisms,

and impact investing, can help address financial sustainability concerns and mobilize resources for smart city initiatives (Albino et al., 2015).

#### **3.4.1.5 Regulatory and Policy Barriers:**

Regulatory frameworks and outdated policies may pose barriers to the adoption and implementation of innovative smart city solutions. Complex regulatory environments, overlapping jurisdictions, and bureaucratic processes can hinder the deployment of new technologies and inhibit experimentation and innovation. Addressing regulatory barriers requires policy reforms, regulatory sandboxes, and agile governance approaches that support experimentation, learning, and adaptation (Nam & Pardo, 2011).

#### **3.4.2 Opportunities in Implementing Smart City Strategy:**

While implementing smart city strategies presents numerous challenges, it also opens up significant opportunities for urban areas to advance towards a more sustainable, efficient, and vibrant future. These opportunities, driven by innovative technologies and data-driven approaches, can transform cities into hubs of efficiency, quality living, and economic growth.

##### **3.4.2.1 Efficiency and Sustainability:**

Smart city strategies offer opportunities to optimize resource use, improve service delivery, and enhance environmental sustainability. By leveraging data analytics and IoT technologies, cities can optimize energy consumption, reduce waste generation, and mitigate environmental impact (Albino et al., 2015).

##### **3.4.2.2 Enhanced Quality of Life:**

Smart city initiatives aim to enhance the quality of life for residents by improving mobility, healthcare, education, and public safety. Smart transportation systems, digital healthcare platforms, and smart infrastructure contribute to safer, healthier, and more livable urban environments (Harrison & Donnelly, 2011).

##### **3.4.2.3 Innovation and Economic Growth:**

Smart cities stimulate innovation and entrepreneurship by creating conducive environments for research, development, and collaboration. Innovation hubs, startup incubators, and digital ecosystems attract talent and investment, driving economic growth and job creation (Bettencourt et al., 2007).

##### **3.4.2.4 Citizen Engagement and Empowerment:**

Smart city strategies promote citizen engagement and participation in decision-making processes, fostering transparency, accountability, and trust in government. Digital platforms, open data initiatives, and participatory planning tools empower residents to contribute to shaping their communities (Nam & Pardo, 2011).

##### **3.4.2.5 Resilience and Adaptability:**

Smart city approaches enhance urban resilience by enabling cities to anticipate, respond to, and recover from various shocks and stresses. From natural disasters to pandemics, smart technologies facilitate real-time monitoring, early warning systems, and adaptive strategies to build resilient communities (Caragliu et al., 2009).

To fully realize these benefits, it is necessary to address these challenges and ensure that smart city initiatives are designed and implemented in a manner that promotes equity, transparency, and accountability. By doing so, we can build a future in which cities are more liveable, resilient, and prosperous for all.

#### 4 Digital Urbanism: Exploring the Nexus of Technology and Urban Development:

The intersection of technology and urban development, often referred to as digital urbanism, represents a transformative paradigm in contemporary urban planning and governance. This section delves into the various dimensions of digital urbanism, focusing on the role of digital technologies in reshaping urban planning processes, tools, and techniques.

##### 4.1 Digital Technologies and Urban Planning: Tools and Techniques:

Digital technologies have revolutionized traditional urban planning practices, offering a plethora of tools and techniques that enable more efficient, inclusive, and data-driven approaches to urban development. This subsection explores the diverse range of digital tools and techniques that are transforming urban planning processes.

- **Geographic Information Systems (GIS):**

GIS platforms have become indispensable tools in urban planning, allowing planners to visualize, analyze, and interpret spatial data to inform decision-making processes. GIS enables the mapping of various urban features, including land use patterns, transportation networks, infrastructure assets, and environmental conditions. By overlaying multiple layers of data, planners can identify spatial relationships, assess potential development impacts, and design interventions that optimize spatial configurations (Longley et al., 2015).

- **Remote Sensing and Satellite Imagery:**

Remote sensing technologies, coupled with satellite imagery and aerial photography, provide valuable insights into urban dynamics, land cover changes, and environmental conditions. Remote sensing data can be used to monitor urban expansion, assess vegetation cover, detect land use changes, and analyze environmental degradation. By leveraging remote sensing technologies, planners gain access to high-resolution spatial data that enhances their understanding of urban



Figure 7 Remote Sensing and Satellite Imagery

Source: <https://www.mdpi.com/>

landscapes and supports evidence-based decision-making (Jensen, 2007).

- **3D Modeling and Visualization:**

Three-dimensional (3D) modeling and visualization tools enable planners to create realistic digital representations of urban environments, allowing stakeholders to visualize proposed development projects and assess their potential impacts. Advanced 3D modeling software facilitates the creation of detailed virtual models that simulate urban landscapes, building designs, and streetscapes. These models can be used for urban design, architectural visualization, public consultation, and urban simulation exercises, enabling stakeholders to explore alternative scenarios and evaluate design options (Jiang et al., 2015).

- **Big Data Analytics:**

The proliferation of digital technologies has led to the generation of vast amounts of urban data, ranging from sensor data and mobile phone records to social media feeds and administrative records. Big data analytics techniques enable planners to harness these large datasets to gain insights into urban trends, behavior patterns, and service demands. By analysing big data, planners can identify emerging trends, predict future urban challenges, and design targeted interventions to address complex urban issues (Kitchin, 2014).

- **Participatory GIS and Citizen Engagement:**

Participatory Geographic Information Systems (PGIS) platforms facilitate citizen engagement in urban planning processes by enabling residents to contribute local knowledge, spatial information, and community perspectives. PGIS tools combine GIS technologies with participatory methods, allowing stakeholders to map community assets, identify priority areas, and collaborate in decision-making processes. By engaging citizens in data collection, analysis, and decision-making, planners can foster inclusive and participatory approaches to urban planning that reflect diverse community needs and aspirations (Nedovic-Budic & Pinto, 2012).

Digital technologies have brought about a major shift in urban planning practices. These technologies offer a wide range of tools and techniques that enable planners to make more informed, data-driven decisions. From GIS and remote sensing to 3D modeling and big data analytics, these digital tools are changing the way cities are planned, designed, and managed, ushering in a new era of digital urbanism.

#### **4.2 Data-Driven Decision Making: Harnessing Information for Urban Development:**

In the era of digital urbanism, data-driven decision making plays a pivotal role in shaping urban development strategies and policies. This section explores the significance of harnessing data for informed decision making in various aspects of urban development.

##### **4.2.1 The Importance of Data in Urban Development:**

Data serves as a cornerstone for evidence-based decision making in urban development. By collecting, analyzing, and interpreting relevant data, city planners and

policymakers gain valuable insights into various facets of urban life, including population demographics, infrastructure utilization, economic activities, environmental conditions, and social dynamics. These insights enable them to identify emerging trends, anticipate future challenges, and design targeted interventions that address the evolving needs of urban communities (Ballas et al., 2017).

#### **4.2.2 Types of Urban Data:**

Urban data encompasses a wide range of sources and formats, including:

##### **1. Census and Demographic Data:**

Census data provides comprehensive information about the demographic characteristics of urban populations, including age distribution, income levels, education attainment, household composition, and ethnic diversity. This data serves as a foundational source for understanding population dynamics and designing socio-economic development programs (United Nations, 2018).

##### **2. Geospatial Data:**

Geospatial data encompasses spatially referenced information about the physical characteristics of urban environments, including land use, transportation networks, building footprints, infrastructure assets, and natural resources. Geospatial data enables planners to visualize urban landscapes, analyze spatial patterns, and assess the spatial relationships between different elements of the built environment (Craglia et al., 2008).

##### **3. Sensor and IoT Data:**

Sensor networks and Internet of Things (IoT) devices generate real-time data about various urban phenomena, including air quality, traffic congestion, energy consumption, waste generation, and weather conditions. These data streams provide timely insights into urban dynamics, enabling proactive decision making and responsive interventions to address emerging issues (Zanella et al., 2014).

##### **4. Administrative Data:**

Administrative records maintained by government agencies and service providers contain valuable information about urban services, expenditures, regulatory permits, and public infrastructure. Administrative data serves as a rich source of information for evaluating the effectiveness of public policies, monitoring service delivery, and assessing the performance of urban systems (McKinney & McKinney, 2017).

#### **4.2.3 Data-Driven Approaches to Urban Development:**

Data-driven decision-making transforms traditional urban planning processes by integrating data analytics, modeling techniques, and visualization tools into planning and policy formulation. This approach involves several key steps:

##### **1. Data Collection and Integration:**

Urban planners collect data from diverse sources and integrate them into centralized data platforms or Geographic Information Systems (GIS). Data integration involves cleaning, processing, and harmonizing disparate datasets to create a unified and comprehensive database that supports analysis and decision-making (Ballas et al., 2017).

## **2. Data Analysis and Modeling:**

Planners use advanced analytics techniques, including statistical analysis, machine learning, and spatial modeling, to extract insights from urban data. Data analysis involves identifying patterns, trends, and correlations within the data to gain a deeper understanding of urban dynamics and inform decision-making (Davies et al., 2015).

## **3. Visualization and Communication:**

Data visualization tools enable planners to communicate complex urban data clearly and intuitively. Visualizations, such as maps, charts, and dashboards, facilitate the communication of key findings, trends, and scenarios to stakeholders, policymakers, and the public, fostering transparency and engagement in urban decision-making (Davies et al., 2015).

## **4. Decision Support Systems:**

Data-driven decision support systems provide planners with actionable insights and recommendations based on data analysis and modeling. These systems leverage algorithms and optimization techniques to evaluate alternative scenarios, assess the potential impacts of policy interventions, and identify optimal strategies for urban development (Ballas et al., 2017).

### **4.2.4 Benefits of Data-Driven Decision Making in Urban Development:**

Data-driven decision-making offers several benefits for urban development:

#### **1. Evidence-Based Policy:**

Data-driven approaches enable policymakers to formulate evidence-based policies and interventions that are grounded in empirical evidence and informed by real-world data.

#### **2. Efficiency and Effectiveness:**

By analysing data and identifying patterns, planners can design more efficient and effective urban development strategies that address priority needs and maximize the impact of limited resources.

#### **3. Innovation and Adaptation:**

Data-driven decision-making fosters innovation and adaptation by enabling planners to respond dynamically to changing urban dynamics, emerging challenges, and technological advancements.

#### **4. Transparency and Accountability:**

By making urban data accessible and transparent, data-driven approaches promote accountability and transparency in urban governance, enabling stakeholders to monitor progress and hold decision makers accountable for their actions (Ballas et al., 2017).

Data-driven decision making is critical for effective urban development. It helps planners and policymakers to better understand complex urban challenges and improve the quality of life for residents. This approach provides valuable insights and evidence-based strategies that can be put into action. By using data to inform decision making, urban development can become more efficient and effective.

## Conclusion:

In conclusion, the exploration of urban evolution in this chapter underscores the rich tapestry of historical legacies, technological advancements, and the emergence of smart cities as transformative forces in shaping urban landscapes. By delving into the historical perspectives on urban growth, we trace the evolution of cities from ancient civilizations to modern metropolises, highlighting key milestones such as the Industrial Revolution that reshaped urban development patterns.

The chapter also sheds light on contemporary trends in urbanization, including the rise of smart cities driven by digital technologies and sustainable practices.

Furthermore, the discussion on challenges and opportunities in urban development emphasizes the need for proactive measures to address issues such as urban infrastructure strain, environmental sustainability, and social equity. Through the strategic integration of technology, sustainability initiatives, and community engagement, cities can chart a course towards a smarter, more livable future that prioritizes efficiency, resilience, and quality of life for all residents.

The chapter underscores the pivotal role of technology in urban transformation, showcasing how innovations in digital tools, materials science, and smart city initiatives are revolutionizing urban spaces and governance structures. The concept of smart cities, with its emphasis on data-driven decision-making and citizen participation, offers a holistic approach to tackling urban challenges and enhancing the overall urban experience.

This chapter advocates for a multidimensional approach to urban development that leverages historical insights and contemporary innovations to create inclusive, resilient, and sustainable urban environments. By drawing inspiration from the past, seizing present opportunities, and fostering collaboration, cities can pave the way for vibrant, future-ready urban spaces that cater to the diverse needs of generations to come.



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## **CHAPTER II :**

# **Energizing Tomorrow: A Review of Smart Cities and Energy- Autonomous Quarters**

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1. Smart Cities and Energy-Autonomous Quarters: A Review
2. Exploring Energy Autonomy in Smart Urban Environments
3. Smart Cities: Pioneering Energy Independence
4. Smart Cities and Autonomous Quarters: Energizing the Future
5. Case Studies in Energy-Autonomous Quarters

### Introduction:

This chapter serves as a comprehensive exploration of the evolving landscape of urban energy systems, shedding light on innovative strategies and initiatives that are reshaping the approach to sustainability and energy independence in cities worldwide.

Central to our discussion is the concept of energy autonomy within smart cities, a multifaceted framework aimed at fostering self-sufficiency and sustainability across all aspects of energy production, distribution, and consumption. By embracing renewable energy generation technologies, smart cities and energy-autonomous quarters are leading the way towards a future where clean and sustainable energy sources drive urban development.

Renewable energy technologies, including biomass energy, play a crucial role in this transition, offering diverse solutions for harnessing natural resources to meet energy demands. From biofuels derived from organic waste streams to biogas produced through anaerobic digestion, these renewable energy sources not only reduce reliance on fossil fuels but also contribute to mitigating environmental impact and promoting energy resilience in urban environments.

As we navigate through the chapters, we will delve into the intricate interplay between technological innovations driving energy independence and community engagement in the energy transition. From smart grid infrastructure optimizing energy flows to demand response programs balancing supply and demand, each aspect contributes to the overarching goal of advancing energy sustainability in smart cities.

Furthermore, this chapter will explore the feasibility of implementing energy-autonomous quarters within smart urban environments, considering factors such as resource availability, technological readiness, and the regulatory environment. By evaluating these key considerations, cities can assess the potential for integrating renewable energy sources, advanced technologies, and community engagement to achieve energy self-sufficiency and environmental resilience.

Embark on this enlightening exploration as we unravel the complexities of smart cities and energy-autonomous quarters, envisioning a future where sustainable energy practices, technological innovations, and community empowerment converge to create vibrant, resilient, and environmentally conscious urban spaces.

## 1. Smart Cities and Energy-Autonomous Quarters: A Review

Energy-autonomous quarters are a promising concept for smart cities. They help achieve energy self-sufficiency and reduce environmental impact. This review explores energy autonomy, renewable energy integration, challenges and opportunities, and the role of smart cities in advancing energy sustainability.

### 1.1 Conceptual Framework of Energy Autonomy:

The conceptual framework of energy autonomy within smart cities is a multifaceted approach aimed at achieving self-sufficiency and sustainability in energy production, distribution, and consumption. It encompasses a range of components and strategies that work synergistically to create resilient and efficient urban energy systems.

Let's delve deeper into each component:

#### 1.1.1 Renewable Energy Generation:

Renewable energy generation encompasses various technologies that harness natural resources to produce clean and sustainable energy. These technologies are vital components of energy autonomy in smart cities and energy-autonomous quarters. Let's explore some of the key renewable energy sources in more detail:

- **Biomass Energy:** Biomass energy encompasses organic materials derived from plants, animals, and organic waste streams, which can be converted into biofuels or used directly for heat and power generation.

- **Biofuels:** Biofuels such as biodiesel and bioethanol are produced from feedstocks such as crops, forestry residues, and organic waste through processes such as fermentation and transesterification (REN21, 2020).
- **Biogas:** Biogas is produced through the anaerobic digestion of organic waste materials such as agricultural residues, food waste, and sewage sludge. Biogas can be used directly for heating or converted into electricity and biomethane for injection into natural gas grids (United Nations Environment Programme, 2021).

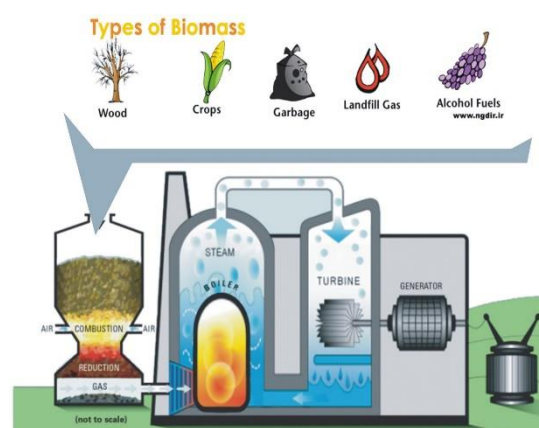


Figure 8 Biomass Systems

Source:

<http://technology2b.blogspot.com/p/electricity.html>

- **Hydropower:** Hydropower is a mature renewable energy technology that utilizes the kinetic energy of flowing water to generate electricity through turbines and generators.

- **Large-Scale Hydropower:** Large-scale hydropower projects involve the construction of dams and reservoirs to regulate water flow and generate electricity on a commercial scale. These projects often have significant environmental and social impacts and are subject to regulatory approval (International Energy Agency, 2021).
- **Small-Scale Hydropower:** Small-scale or micro-hydropower systems are suitable for decentralized energy generation in rural or remote areas with access to flowing water sources such as rivers or streams. These systems can provide electricity for off-grid communities or supplement grid-connected systems (REN21, 2020).

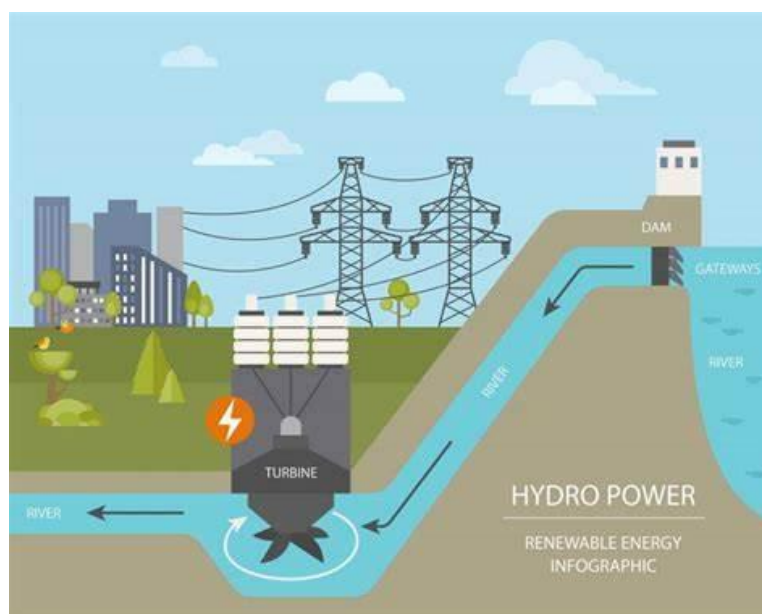


Figure 9 Hydropower System

Source: <https://www.shutterstock.com/search/infographic-hydropower>

- **Geothermal Energy:** Geothermal energy harnesses the heat stored beneath the Earth's surface to generate electricity and provide heating and cooling for buildings. This renewable energy source is abundant and reliable, offering a continuous and low-carbon alternative to fossil fuels. Geothermal energy is categorized into three main types:
  - **Hydrothermal Systems:** These systems utilize naturally occurring hot water and steam reservoirs located close to the Earth's surface. Wells are drilled to access the geothermal fluids, which are then used directly for heating or to generate electricity through steam turbines. (DiPippo, R.2012)
  - **Enhanced Geothermal Systems (EGS):** EGS involve artificially stimulating deep, hot rock formations to create permeability and extract heat. This process typically involves injecting water into the rock formations at high pressure to create fractures and increase permeability, allowing for the circulation of water through the reservoir to extract heat. (Tester, J. W., et al.2006)
  - **Geothermal Heat Pumps:** Geothermal heat pumps utilize the relatively constant temperature of the Earth's subsurface to provide heating, cooling, and hot water for

residential and commercial buildings. These systems transfer heat between the ground and the building using a network of pipes and a heat pump, significantly reducing energy consumption for heating and cooling. (Lund, J. W., & Boyd, T. L. (Eds.). 2016)

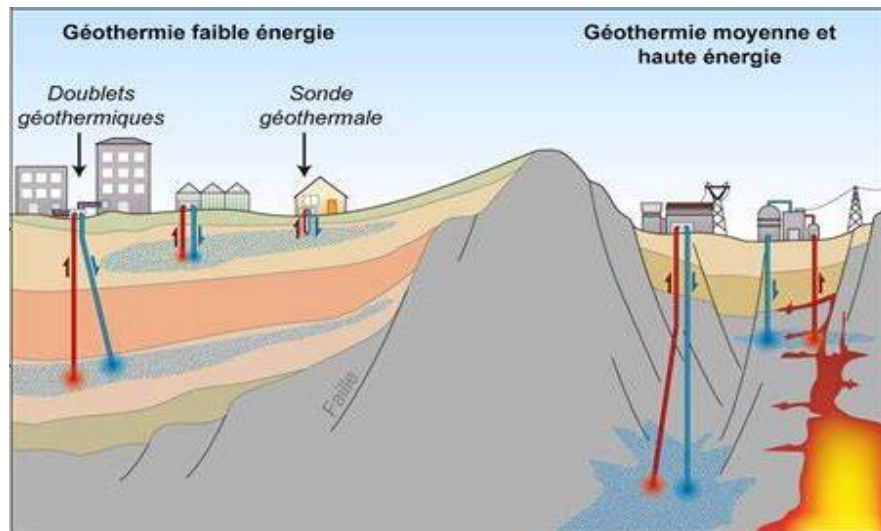


Figure 10 Geothermal System

Source: <http://blog.ametrargroup.com/geothermie-energie-verte/>

- **Solar Energy:** Solar energy is one of the most abundant and widely available renewable energy sources, offering significant potential for decentralized energy generation in urban areas. Solar energy technologies can be broadly categorized into two main types: solar photovoltaic (PV) and solar thermal.

- **Solar Photovoltaic (PV) Systems:** Solar PV systems convert sunlight directly into electricity using photovoltaic cells, which are typically made of silicon-based semiconductor materials. These systems can be deployed on rooftops, facades, or ground-mounted installations within urban environments (REN21, 2020).
- **Solar Thermal Systems:** Solar thermal systems harness solar radiation to generate heat for various applications such as water heating, space heating, and industrial processes. These systems typically

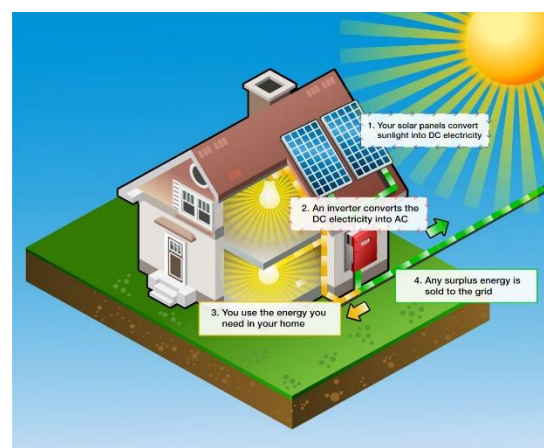


Figure 11 Solar Photovoltaic (PV) Systems

Source: [www.greensphergroup.com](http://www.greensphergroup.com)

consist of solar collectors, heat transfer fluids, and thermal storage units (International Energy Agency, 2021).

- **Wind Energy:** Wind energy is another abundant and widely distributed renewable energy resource that can be harnessed for electricity generation in urban and peri-urban areas. Wind turbines convert kinetic energy from wind into mechanical power, which is then converted into electricity using generators.
  - **Onshore Wind Turbines:** Onshore wind turbines are installed on land and can vary in size from small-scale turbines suitable for residential or community use to utility-scale turbines deployed in wind farms (United Nations Environment Programme, 2021).
  - **Offshore wind turbines** are installed in bodies of water, typically in coastal areas or offshore wind farms. Offshore wind offers the advantage of higher wind speeds and reduced visual impact compared to onshore wind installations (International Energy Agency, 2021).

### 1.1.2 Energy Storage Systems:

Energy storage systems are essential for ensuring a stable and reliable energy supply in smart cities, particularly when relying on intermittent renewable energy sources. These systems store excess energy during periods of low demand or high generation and release it when needed.

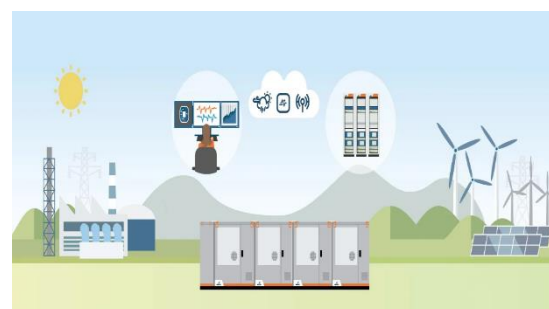


Figure 12 Energy Storage Systems

Source: <https://www.wisein.org/>

- **Battery Storage:** Lithium-ion batteries, flow batteries, and other advanced battery technologies store electricity for later use, providing backup power during outages and stabilizing the grid.
- **Pumped Hydro Storage:** Pumped hydroelectric storage facilities use surplus electricity to pump water from a lower reservoir to a higher reservoir during off-peak hours. When electricity demand rises, water is released back to the lower reservoir through turbines to generate electricity.
- **Thermal Energy Storage:** Thermal energy storage systems store heat or cold generated from renewable energy sources, such as solar thermal or geothermal energy, for later use in heating, cooling, or power generation.

### 1.1.3 Smart Grid Technologies:

Smart grid technologies form the backbone of energy autonomy in smart cities, enabling real-time monitoring, control, and optimization of energy flows within the urban grid.

- **Advanced Metering Infrastructure (AMI):** Smart meters equipped with communication capabilities provide real-time data on energy consumption, enabling consumers to monitor and manage their energy usage more effectively.
- **Distributed Energy Resources (DERs):** DERs, including rooftop solar panels, wind turbines, and energy storage systems, are integrated into the grid to enhance reliability, resilience, and efficiency.
- **Demand Response (DR):** DR programs incentivize consumers to adjust their energy consumption patterns in response to supply conditions or grid constraints, reducing peak demand and balancing the grid.
- **Grid Automation and Control:** Automated control systems optimize energy distribution, minimize losses, and detect and respond to faults or disturbances in the grid in real time, improving overall grid stability and reliability.

#### **1.1.4 Energy Efficiency Measures:**

Energy efficiency measures play a crucial role in reducing overall energy consumption and maximizing the effectiveness of energy autonomy strategies in smart cities.

- **Building Energy Efficiency:** Passive design strategies, energy-efficient building materials, insulation, and high-performance windows and doors minimize heat loss and gain, reducing the need for heating, cooling, and lighting.
- **Smart Appliances and Equipment:** Energy-efficient appliances, HVAC systems, lighting fixtures, and smart thermostats incorporate advanced technologies to optimize energy usage and reduce wastage.
- **Transportation Efficiency:** Electrification of transportation, promotion of public transit, implementation of bike-sharing and car-sharing programs, and adoption of intelligent transportation systems (ITS) reduce energy consumption and emissions associated with urban mobility.

#### **1.2 Challenges and Opportunities for Energy Integration in Smart Urban Areas:**

The integration of energy systems within smart urban areas presents both challenges and opportunities that are crucial to understand for effective urban energy management (Craglia et al., 2008).

##### **1.2.1 Challenges:**

1. **Complex Energy Infrastructure:** Smart urban areas consist of diverse energy infrastructure, including electricity grids, heating and cooling systems, transportation networks, and renewable energy sources. Coordinating these complex systems to ensure efficient energy distribution and utilization poses a significant challenge for urban planners and policymakers (Davies et al., 2015).
2. **Interdisciplinary Coordination:** Energy integration in smart urban areas requires collaboration across various disciplines, including urban planning, architecture, engineering, and environmental science. Achieving interdisciplinary coordination and alignment of goals and strategies presents a challenge due to the diverse stakeholders

involved and the need for integrated planning approaches (McKinney & McKinney, 2017).

3. **Data Management and Analytics:** The abundance of data generated by smart urban infrastructure, including energy consumption data, renewable energy production data, and environmental monitoring data, presents challenges related to data management, integration, and analysis. Ensuring the security, privacy, and interoperability of data while extracting actionable insights for energy management is a complex task (United Nations, 2018).
4. **Regulatory and Policy Barriers:** Regulatory frameworks and policy barriers at the local, national, and international levels can hinder the integration of innovative energy technologies and practices in smart urban areas. Overcoming regulatory hurdles and fostering policy coherence to support energy innovation and sustainability is essential for effective energy integration (Zanella et al., 2014).

### **1.2.2 Opportunities:**

1. **Renewable Energy Integration:** Smart cities offer opportunities for the integration of renewable energy sources, such as solar photovoltaics, wind turbines, and geothermal systems, into urban energy systems. By harnessing renewable energy, smart urban areas can reduce dependency on fossil fuels, lower greenhouse gas emissions, and enhance energy resilience (Ballas et al., 2017).
2. **Energy Efficiency and Demand Response:** Smart urban technologies, including smart meters, building automation systems, and demand response mechanisms, enable improved energy efficiency and demand-side management. By optimizing energy use and shifting peak demand, smart cities can reduce energy consumption, lower costs, and enhance grid stability (Craglia et al., 2008).
3. **Decentralized Energy Systems:** Decentralized energy systems, such as microgrids and district heating and cooling networks, offer opportunities for localized energy generation, distribution, and storage within smart urban areas. These systems enhance energy resilience, reduce transmission losses, and support community-based energy initiatives (Davies et al., 2015).
4. **Data-Driven Decision Making:** The proliferation of data analytics and digital technologies enables data-driven decision making for energy management in smart urban areas. By leveraging real-time data analytics, predictive modeling, and optimization algorithms, cities can optimize energy systems, plan infrastructure investments, and address emerging energy challenges (McKinney & McKinney, 2017).

### **1.2.3 The Role of Smart Cities in Energy Sustainability:**

Smart cities play a pivotal role in advancing energy sustainability through the integration of renewable energy and the promotion of energy-autonomous quarters. Key roles of smart cities include:

- **Policy Leadership:** Smart cities develop and implement policies and regulations that promote renewable energy adoption, energy efficiency, and sustainable urban development. Policy instruments such as renewable energy targets, feed-in tariffs, and energy performance standards incentivize investment in renewable energy and drive market transformation (Rosenow & Eyre, 2013).
- **Infrastructure Investment:** Smart cities invest in renewable energy infrastructure, grid modernization, and energy storage systems to support renewable energy integration and energy autonomy. Strategic investments in smart grid technologies, energy-efficient buildings, and sustainable transportation systems lay the foundation for a resilient and sustainable energy future (Farang et al., 2020).
- **Technological Innovation:** Smart cities drive technological innovation in renewable energy generation, storage, and distribution. Research and development initiatives, public-private partnerships, and innovation ecosystems foster the development and deployment of cutting-edge renewable energy technologies, driving down costs and improving efficiency (Dudek & Phillips, 2019).
- **Community Engagement:** Smart cities engage residents, businesses, and community stakeholders in energy sustainability initiatives through education, outreach, and participatory decision-making processes. Community-based energy projects, energy cooperatives, and citizen-led initiatives empower individuals and communities to take ownership of their energy future and contribute to a more sustainable urban environment (Joss et al., 2019).

In conclusion, the integration of renewable energy into smart urban areas, including the development of energy-autonomous quarters, holds great promise for advancing energy sustainability, reducing environmental impact, and enhancing the resilience of urban communities. Despite challenges such as intermittency and grid integration, smart cities play a crucial role in overcoming barriers and seizing opportunities to create a more sustainable and resilient energy future.

## 2. Exploring Energy Autonomy in Smart Urban Environments:

The pursuit of energy autonomy within smart urban environments represents a significant step towards sustainable development and resilience. This section delves into various aspects of energy autonomy, including urban planning for energy efficiency, technological innovations driving energy independence, and the feasibility of implementing energy-autonomous quarters.

### 2.1 Urban Planning for Energy Efficiency:

Urban planning plays a critical role in fostering energy efficiency within smart urban environments. Key considerations include:

- **Compact Urban Design:** Compact urban design promotes mixed land use, higher density development, and efficient transportation systems, reducing energy consumption associated with sprawl and facilitating access to amenities and services (Newman & Kenworthy, 2015).
- **Green Building Standards:** Incorporating green building standards and codes into urban planning ensures that new developments meet energy efficiency and sustainability criteria, reducing energy demand and environmental impact (Chen et al., 2019).
- **Transit-Oriented Development:** Transit-oriented development encourages the development of compact, walkable neighborhoods with access to public transit, reducing reliance on private vehicles and lowering energy consumption for transportation (Cervero & Kockelman, 1997).
- **Renewable Energy Integration:** Urban planning strategies should prioritize the integration of renewable energy sources, such as solar panels on rooftops and wind turbines in urban areas, to generate clean, locally sourced energy (Baker & Steemers, 2002).

### 2.2 Technological Innovations Driving Energy Independence:

Technological innovations are driving energy independence within smart urban environments, enabling the efficient generation, storage, and management of energy resources. Key innovations include:

- **Distributed Energy Resources:** Distributed energy resources, including rooftop solar panels, small-scale wind turbines, and micro-CHP systems, enable decentralized energy generation and enhance energy resilience within communities (Fang et al., 2017).
- **Smart Grid Technologies:** Smart grid technologies facilitate real-time monitoring, control, and optimization of energy distribution networks, enabling dynamic demand-response mechanisms and improving grid efficiency and reliability (Farhangi, 2010).
- **Energy Storage Solutions:** Advances in energy storage technologies, such as lithium-ion batteries, flow batteries, and thermal storage systems, enable the efficient storage

of renewable energy for later use, enhancing grid stability and enabling higher penetration of renewable energy sources (Yunus et al., 2018).

- **Demand-Side Management Systems:** Demand-side management systems utilize smart meters, sensors, and control systems to optimize energy consumption patterns, reduce peak demand, and enhance energy efficiency within buildings and urban infrastructure (Faruqui & Sergici, 2010).

### 2.3 Evaluating the Feasibility of Energy-Autonomous Quarters:

The feasibility of implementing energy-autonomous quarters within smart urban environments depends on various factors, including technological, economic, and regulatory considerations:

- **Resource Availability:** Evaluating the availability of renewable energy resources such as solar irradiance, wind speed, and biomass potential in the target urban area. Resource assessments help determine the feasibility and potential scale of renewable energy generation within energy-autonomous quarters (Lu et al., 2017).
- **Technological Readiness:** Assessing the maturity and suitability of renewable energy and energy storage technologies for integration into energy-autonomous quarters. Technological readiness assessments consider factors such as technology cost, performance, reliability, and scalability to ensure the feasibility of energy autonomy solutions (Peng et al., 2017).
- **Regulatory Environment:** Analyzing regulatory frameworks, policies, and incentives related to renewable energy deployment, energy efficiency, and grid integration. Understanding the regulatory environment helps identify barriers and opportunities for implementing energy-autonomous quarters and navigating regulatory challenges (Figueiredo et al., 2018).
- **Economic Viability:** Conducting cost-benefit analyses and financial assessments to evaluate the economic viability of energy-autonomous quarters. Economic feasibility studies consider factors such as upfront capital costs, operational expenses, energy savings, revenue generation potential, and return on investment to determine the financial feasibility of energy autonomy solutions (Klessmann et al., 2011).

In conclusion, exploring energy autonomy in smart urban environments involves urban planning strategies for energy efficiency, technological innovations driving energy independence, and rigorous evaluations of the feasibility of energy-autonomous quarters. By integrating energy autonomy principles into urban development processes, cities can enhance sustainability, resilience, and quality of life for residents while reducing their environmental footprint.

## 3. Smart Cities: Pioneering Energy Independence

Smart cities use advanced technologies and innovative strategies to enhance energy efficiency, promote renewable energy integration, and empower communities in their

transition towards sustainable energy systems. This includes smart grids and energy management systems, community engagement in the energy transition, economic and social impacts of energy independence, and international perspectives on smart city energy initiatives.

### **3.1 Smart Grids and Energy Management Systems:**

The development of smart grids and advanced energy management systems plays a crucial role. These systems will not only optimize energy production and consumption but also enhance the overall efficiency and reliability of the energy infrastructure.

#### **3.1.1 Smart Grid Infrastructure:**

Smart cities deploy intelligent grid infrastructure equipped with sensors, meters, and automation technologies to optimize energy generation, distribution, and consumption. Smart grids enable real-time monitoring, control, and optimization of energy flows, improving grid reliability, resilience, and efficiency (Farhangi, 2010).

#### **3.1.2 Demand Response Programs:**

Smart energy management systems implement demand response programs that incentivize consumers to adjust their electricity usage in response to supply conditions and grid constraints. Demand response strategies help balance supply and demand, reduce peak loads, and enhance grid stability, contributing to energy efficiency and cost savings (Hao et al., 2017).

#### **3.1.3 Energy Analytics and Optimization:**

Advanced analytics and optimization algorithms analyze energy data to identify patterns, forecast demand, and optimize energy consumption. Energy management platforms leverage artificial intelligence (AI) and machine learning (ML) techniques to optimize building operations, schedule energy-intensive tasks, and minimize energy waste, enhancing overall energy efficiency (Lu et al., 2017).

### **3.2 Community Engagement and Energy Transition:**

Successful energy transition relies on active community engagement and education. Involving residents ensures a shared understanding and commitment to sustainable practices.

#### **3.2.1 Energy Awareness and Education:**

Smart cities engage communities through energy awareness campaigns, educational programs, and outreach initiatives to raise awareness about energy conservation, renewable energy options, and sustainable lifestyle choices. Community-based workshops, seminars, and events empower residents to adopt energy-efficient practices and participate actively in the energy transition (Janda, 2016).

**3.2.2 Citizen-Centric Energy Initiatives:**

Community engagement platforms and participatory decision-making processes enable residents to contribute ideas, feedback, and suggestions for local energy projects and initiatives. Citizen-centric energy initiatives, such as community solar programs, energy cooperatives, and neighborhood energy hubs, foster a sense of ownership and collaboration in the energy transition (Dahiya et al., 2017).

**3.2.3 Social Equity and Inclusion:**

Smart cities prioritize social equity and inclusion in energy transition efforts by ensuring that vulnerable and marginalized communities have access to affordable and clean energy solutions. Energy equity programs, financial assistance schemes, and targeted outreach efforts address energy poverty and promote energy justice, ensuring that all residents benefit from the transition to sustainable energy systems (Sovacool et al., 2019).

**3.3 Economic and Social Impacts of Energy Independence:****3.3.1 Economic Growth and Job Creation:**

Energy independence initiatives stimulate economic growth and job creation by fostering innovation, attracting investment, and creating new opportunities in the clean energy sector. Renewable energy projects, energy efficiency retrofits, and smart grid deployments generate employment across various industries, driving economic development and prosperity (Mazzucato, 2013).

**3.3.2 Cost Savings and Financial Resilience:**

Energy independence measures, such as energy efficiency improvements and renewable energy adoption, result in cost savings for residents, businesses, and local governments. Reduced energy bills, avoided infrastructure investments, and enhanced energy security contribute to financial resilience and economic stability, freeing up resources for other priorities (Blyth et al., 2019).

**3.3.3 Social Cohesion and Quality of Life:**

Energy independence initiatives enhance social cohesion and quality of life by fostering community resilience, reducing environmental risks, and improving public health outcomes. Clean energy technologies, sustainable transportation options, and green spaces create healthier and more livable urban environments, enhancing the well-being and happiness of residents (Eckersley et al., 2016).

**3.4 International Perspectives on Smart City Energy Initiatives:****3.4.1 Policy and Regulatory Frameworks:**

International smart city initiatives highlight the importance of supportive policy and regulatory frameworks for promoting energy independence. Best practices include establishing renewable energy targets, implementing feed-in tariffs, and enacting energy

efficiency standards to incentivize investment and drive market transformation (United Nations, 2019).

### **3.4.2 Technological Innovation:**

International collaboration and knowledge exchange facilitate technological innovation and best practice sharing in smart city energy initiatives. Cross-border partnerships, research networks, and demonstration projects enable cities to learn from each other, adopt proven solutions, and accelerate the deployment of clean energy technologies (International Energy Agency, 2018).

### **3.4.3 Capacity Building and Knowledge Sharing:**

International smart city networks and organizations provide platforms for capacity building, knowledge sharing, and peer learning in energy independence initiatives. Collaborative initiatives, such as city twinning programs, expert workshops, and online platforms, enable cities to exchange experiences, address common challenges, and develop joint solutions for sustainable urban energy development (European Commission, 2020).

Smart cities are using innovative methods to achieve energy independence through smart grids, community involvement, and international cooperation, while considering economic and social impacts. Advanced technologies, community participation, and global best practices can pave the way towards a sustainable and resilient energy future.

## **4. Smart Cities and Autonomous Quarters: Energizing the Future:**

In the pursuit of sustainable urban development, smart cities are embracing the concept of autonomous quarters to energize the future. These quarters, empowered by smart technologies and community participation, aspire to achieve energy self-sufficiency while adhering to robust policy frameworks. This section explores the vision of energy-autonomous quarters, the role of smart technologies in enabling energy self-sufficiency, community participation in sustainable energy initiatives, and the necessary policy frameworks for scaling up these innovative urban spaces.

### **4.1 The Vision of Energy-Autonomous Quarters:**

Energy-autonomous quarters meet urban energy demands sustainably by locally producing, managing, and consuming energy. This section delves into key aspects

#### **4.1.1 Decentralized Energy Production:**

Energy-autonomous quarters envision a decentralized energy production model where buildings and communities generate their own renewable energy. This vision entails rooftop solar panels, small-scale wind turbines, and other distributed energy resources integrated into the built environment to meet local energy demands (Farhangi, 2010).

**4.1.2 Energy Sharing and Optimization:**

These quarters prioritize energy sharing and optimization through smart grids and microgrids, enabling surplus energy generated by one building or block to be shared with others in the vicinity. Energy optimization algorithms and demand response strategies ensure efficient use of resources, reducing waste and enhancing overall energy resilience (Hao et al., 2017).

**4.1.3 Circular Economy Principles:**

Embracing circular economy principles, energy-autonomous quarters aim to minimize waste and maximize resource efficiency. Integrated systems for waste-to-energy conversion, rainwater harvesting, and urban agriculture contribute to a closed-loop approach, where resources are recycled and reused within the local ecosystem (Ellen MacArthur Foundation, 2015).

**4.2 Smart Technologies Enabling Energy Self-Sufficiency:**

In the pursuit of energy self-sufficiency, integrating smart technologies plays a pivotal role. One such technology is the Internet of Things (IoT), and other technologies let's explore them :

**4.2.1 Internet of Things (IoT) Integration:**

Smart technologies form the backbone of energy-autonomous quarters, with IoT devices embedded in buildings, infrastructure, and energy systems. These devices enable real-time monitoring, control, and optimization of energy consumption, allowing residents and building managers to make data-driven decisions to reduce energy waste (Zhang et al., 2019).

**4.2.2 Artificial Intelligence (AI) and Predictive Analytics:**

AI algorithms and predictive analytics play a crucial role in energy management systems within autonomous quarters. By analyzing historical data, weather patterns, and occupancy trends, AI systems can anticipate energy demand, optimize building operations, and adjust energy production schedules to maximize efficiency and cost savings (Albadi & El-Saadany, 2008).

**4.2.3 Blockchain for Energy Transactions:**

Blockchain technology facilitates transparent and secure energy transactions within autonomous quarters. Smart contracts executed on blockchain platforms enable peer-to-peer energy trading, where residents can buy, sell, or exchange surplus energy directly with their neighbors, fostering a decentralized and democratized energy marketplace (Lund et al., 2020).

**4.3 Community Participation in Sustainable Energy Initiatives:****4.3.1 Citizen Co-creation and Engagement:**

Community participation is integral to the success of energy-autonomous quarters. Residents, businesses, and local stakeholders are actively involved in co-creating sustainable energy initiatives, providing input on energy system design, participating in energy conservation programs, and advocating for renewable energy adoption (Jenkins et al., 2016).

#### **4.3.2 Energy Literacy and Education:**

Empowering residents with energy literacy and education programs enhances their understanding of sustainable energy concepts and technologies. Workshops, training sessions, and informational campaigns educate community members about energy efficiency practices, renewable energy options, and the benefits of energy autonomy, fostering a culture of sustainability (Krebs et al., 2020).

#### **4.3.3 Community Energy Cooperatives:**

Community energy cooperatives enable collective ownership and management of renewable energy assets within autonomous quarters. Residents pool resources to invest in shared solar arrays, wind farms, or energy storage systems, allowing them to benefit collectively from clean energy generation and financial returns (Devine-Wright & Devine-Wright, 2017).

### **5. Case Studies in Energy-Autonomous Quarters:**

#### **5.1 Kashiwa-no-ha, Japan: Energy-Autonomous Quarters**

**Overview:** Kashiwa-no-ha, located in Kashiwa City, Japan, is a pioneering smart eco-town designed with energy-autonomous features to promote sustainable urban living. The development integrates renewable energy sources, advanced technologies, and community engagement to achieve energy self-sufficiency and environmental resilience.

##### **Key Features:**

- **Solar Power Generation:** Kashiwa-no-ha incorporates extensive solar power generation facilities, including rooftop solar panels on residential and commercial buildings, solar carports in parking lots, and solar farms in surrounding green spaces. These solar installations harness sunlight to generate clean electricity for local consumption.
- **Energy-Efficient Buildings:** The eco-town features energy-efficient building designs with high-performance insulation, LED lighting, and energy-efficient appliances. Passive solar design principles are applied to maximize natural lighting and thermal comfort while minimizing energy demand for heating and cooling.
- **District Energy Systems:** Kashiwa-no-ha utilizes district energy systems for centralized heating and cooling services. Combined heat and power (CHP) plants, heat pumps, and thermal storage technologies provide efficient heating and cooling to buildings, reducing energy consumption and greenhouse gas emissions.

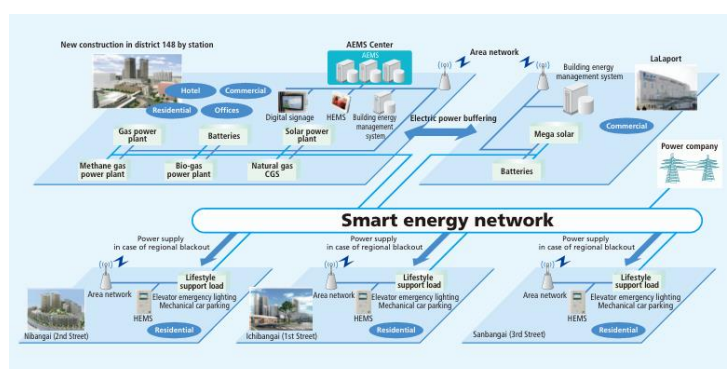


Figure 13 Smart energy network

Source: [www.mitsuifudosan.co.jp](http://www.mitsuifudosan.co.jp)

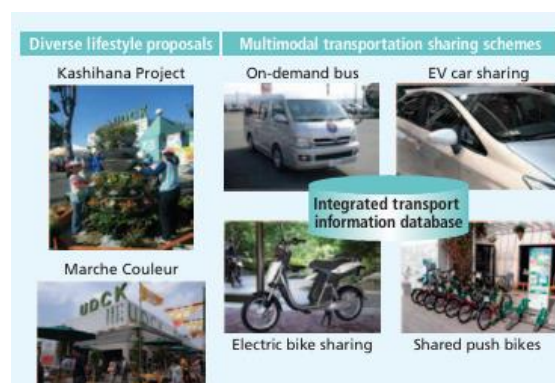
### Technological Solutions:

- **Smart Grid Integration:** The eco-town is equipped with a smart grid infrastructure that enables real-time monitoring, control, and optimization of energy distribution. Smart meters, sensors, and communication networks facilitate data exchange between utility providers and consumers, allowing for demand response and grid stability.
- **Energy Storage Technologies:** Battery energy storage systems (BESS) and thermal storage units are deployed to store surplus energy generated from renewable sources. These energy storage solutions enhance grid resilience, support intermittent renewable energy generation, and provide backup power during grid outages.
- **Building Energy Management Systems (BEMS):** Buildings in Kashiwa-no-ha are equipped with BEMS for intelligent energy management. BEMS optimize energy consumption through automated controls, occupancy sensors, and predictive algorithms, ensuring efficient operation and occupant comfort while minimizing energy waste.

### Community Involvement:

- **Community Energy Cooperatives:** Residents participate in community energy cooperatives that invest in renewable energy projects and energy efficiency initiatives. These cooperatives enable collective ownership of renewable energy assets, fostering community engagement and financial participation in sustainable energy solutions.
- **Energy Awareness Programs:** Kashiwa-no-ha conducts energy awareness programs and workshops to educate residents about energy conservation and renewable energy technologies. Residents learn practical tips for reducing energy consumption, optimizing energy use, and contributing to the eco-town's sustainability goals.
- **Green Mobility Initiatives:**

The eco-town promotes green mobility options such as electric vehicles (EVs), bike-sharing programs, and pedestrian-friendly infrastructure. EV charging stations, bike lanes, and walking paths encourage residents to adopt sustainable transportation modes, reducing carbon emissions and promoting active lifestyles.



## Policy Support:

Figure 14 Green Mobility

- Government Subsidies and Incentives:** The Japanese government provides subsidies and incentives to promote renewable energy adoption and energy efficiency in buildings. Feed-in tariffs, tax incentives, and low-interest loans encourage investments in solar power generation, energy-efficient appliances, and building retrofits.
- Regulatory Framework:** Japan has established regulatory frameworks and building codes to promote energy efficiency and renewable energy integration in urban developments. Building standards mandate energy performance requirements, solar-ready designs, and green building certifications, ensuring that eco-town projects comply with sustainability guidelines.
- Public-Private Partnerships (PPP):** Kashiwa-no-ha is developed through public-private partnerships involving government agencies, private developers, and academic institutions. These collaborations facilitate the implementation of innovative energy solutions, research collaborations, and knowledge sharing to advance sustainable urban development practices.

Source: [www.mitsui-fudosan.co.jp](http://www.mitsui-fudosan.co.jp)

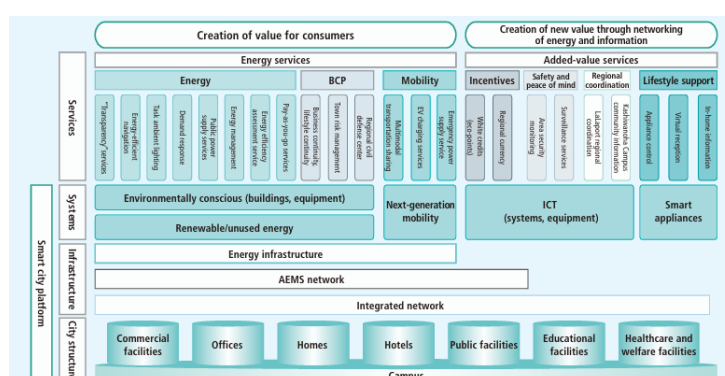


Figure 15 Public-Private Partnerships (PPP)

Source: [www.mitsui-fudosan.co.jp](http://www.mitsui-fudosan.co.jp)

## **5.2 Masdar City, UAE: Energy-Autonomous Quarters:**

### **5.2.1 Overview:**

A laboratory city in the land of black gold," Masdar: A location characterized by abundant blue skies, constant sunshine, vast expanses of desert, and a complete absence of water. Nonetheless, this place is named "the source" (a translation of the Arabic word "MASDAR"). Welcome to Masdar City, a technological oasis covering 7 km<sup>2</sup>, or perhaps a mirage, depending on one's perspective (FIGARO, 2015).

Located 20 km from Abu Dhabi International Airport, MASDAR City is a remarkable and innovative project. The fundamental idea was to build a fully sustainable city from scratch in an undeveloped desert area. MASDAR was conceived as a testing ground for large-scale experimentation with clean technologies and renewable energy projects. The project has been funded by the substantial oil revenues of the UAE, with a total cost of 16 billion dollars (14.4 billion euros).

Initiated in 2008, this 6 km<sup>2</sup> "city of the future," whose name translates to "source" in Arabic, was designed to accommodate 52,000 residents and create 40,000 jobs. Initially scheduled for completion in 2016, the projected completion date has been extended to 2030 at the earliest. The "eco-city," intended to be powered by renewable energy, feature a non-polluting transportation network and ensure total waste recycling, remains unfinished (BNP, 2014).



*Figure 16 Geographical Location of the City of Masdar*

*Source: (Andy, 2016)*

### **5.2.2 Project Concept:**

The city was planned by the architectural firm "Foster and Partners," blending traditional Middle Eastern architecture and urbanism with modern technologies (Chynoweth, 2017).



*Figure 17 Overview of the City of MASDAR;*

*Source: (DHAOUADI, 2018)*

### 5.2.3 Methods and Tools of MASDAR City:

MASDAR City is recognized as an exemplary smart city, with the stated objectives of positioning the UAE as a central player in the renewable energy sector, thereby complementing its status as a major hydrocarbon exporter. To achieve these aims, a variety of methods and tools have been implemented to develop a sustainable and distinctive city, enhancing the management of objectives and capital, as analyzed below (BNP, 2014):

#### 5.2.3.1 Smart Governance:

The project is structured into five distinct entities:

- **Masdar City:** This entity encompasses all aspects of urban planning and the utilization of clean energy.
- **Masdar Institute:** Dedicated to overseeing all research programs initiated concurrently to support the project. Currently, 180 scientists from 25 different countries are engaged in research at the Massachusetts Institute of Technology laboratories, in collaboration with the UAE government.
- **Masdar Power and Masdar Carbon:** These entities focus on the production and recycling of clean energy, as well as the optimal management of carbon emissions within the city.
- **Masdar Capital:** This entity manages all project funds, which are invested in the production of renewable energy, the development of appropriate services, and the execution of scientific research programs (BNP, 2014).

#### 5.2.3.2 Environmental Engagement:

Masdar City places considerable emphasis on the strategic utilization of environmental resources. This concept, while broadly applicable to various natural resource extraction endeavors, assumes particular significance within the framework of Masdar's sustainability objectives. The city's commitment to sustainability extends to minimizing both economic and environmental footprints, setting it apart as a notable exemplar in this regard.



Figure 18 Zoning of Masdar City

Source: (SADKAOUI, 2018)

The intrinsic design of Masdar City is conceived to harness and contend with environmental dynamics. Nestled within an arid desert expanse, Masdar City confronts what might seem to be a formidable obstacle. Yet, paradoxically, this setting emerges as its paramount advantage. Although devoid of many essential resources crucial for sustenance, deserts abound in two pivotal elements that can underpin the construction of an entire contemporary urban center: wind and sunlight (Anderson, 2016).

- **Wind:**

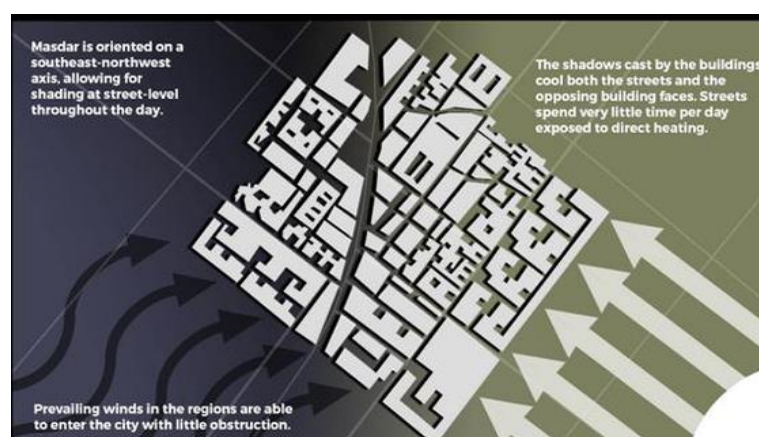


Figure 19 Infographic

Source: (Thies, A. & Howe, J., 2016)

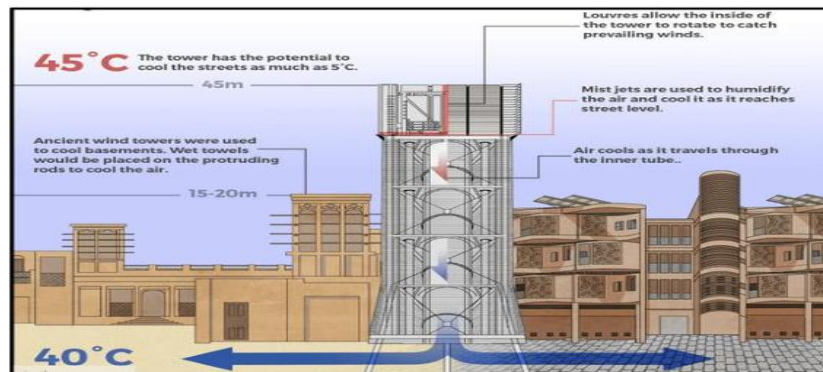


Figure 20 Infographic

Source: (Thies, A. & Howe, J., 2016)

Cities develop street networks based on various considerations. Some orient streets from north to south to facilitate navigation. Others position them parallel to a river. Masdar's streets are narrow and short to allow the wind to traverse the street landscape, sweeping away stale, warm air. Could Masdar City actively harness the wind to significantly cool the city? The answer lies in wind towers (Anderson, 2016).

- Solar Energy:

In pursuit of improved well-being and operational efficiency, Masdar City integrates the three most commercially viable types of solar panels to harness solar energy for electricity generation. Currently, the city derives approximately 70% of its energy from expansive solar fields encircling its perimeter.



Figure 21 Solar Fields

Source: (Ebrahim, 2017)

Furthermore, solar panels adorning the rooftops of the Masdar Institute contribute up to one-third of the city's energy consumption. However, a significant challenge in solar

energy production within Masdar stems from sand abrasion. Following dust storms, the accumulation of sand layers on panels markedly diminishes energy production efficiency. Presently, manual cleaning procedures are necessitated to address this issue. Yet, researchers at the Institute are spearheading the development of sand-resistant solar panels. This pioneering initiative involves the refinement of material pore sizes to inhibit sand adhesion (Anderson, 2016).

In addition, the integration of moucharabieh in building facades not only facilitates natural ventilation but also mitigates direct sunlight infiltration into living spaces. This architectural feature enables light transmission through 30% of the glass surface, balancing illumination and thermal comfort (FIGARO, 2015).



*Figure 22 Moucharabieh Housing Facades*

*Source: urban-hub (Accessed on: December 20, 2018)*

- **Waste Management:** The city implements recycling and reusing waste as integral components of its waste management strategy.

Recycled wastewater is utilized for irrigation in food crop cultivation, aiming to reduce seawater desalination consumption by 80%. This reduction is significant given the substantial energy requirements of desalination processes (Garg, 2011).

- **Sustainable Transportation:**

Masdar City adopts an energy-efficient and greenhouse gas emission-free public transportation system known as Personal Rapid Transit (PRT). This system employs simple vehicle units akin to cars but operates on guided rail tracks similar to traditional mass transit. The objective is to establish a clean and highly efficient public transportation system while preserving individual mobility (Mubadala, 2013).



*Figure 23 ECO-CAR Masdar city.*

*Source (PRT, 2017)*

There are also other types:



*Figure 24 NAVYA BUS*

*Source: prtconsulting.com (Accessed on: February 22, 2019)*



*Figure 25 ECO BUS*

*Source: atlaslen.com (Accessed on: January 22, 2019)*

- **Eco House:**

The eco-villa epitomizes a revolutionary approach to residential energy consumption, significantly outperforming its traditional counterparts by consuming less than a quarter of their energy. This achievement is attributable to its meticulous design and reliance on renewable energy sources. Spanning 405 square meters, this Eco-Villa stands as a trailblazer, securing the prestigious 4-Pearl rating within the Estidama Pearl Building Rating System, sanctioned by the Department of Urban Planning and Municipalities of Abu Dhabi. Compared to its Abu Dhabi counterparts, this dwelling showcases an impressive reduction of approximately 72% in energy consumption and 35% in water usage, effectively curbing an estimated 63 tons of annual carbon dioxide emissions.

Noteworthy is its competitive construction cost, mirroring that of conventional houses of similar dimensions. Equipped with 87 rooftop solar panels, this four-bedroom residence boasts the capability to inject up to 40,000 kWh of electricity into the national grid (Mubadala, 2018).



*Figure 26 Masdar City Eco-Villa*

*Source: (Mubadala, 2018)*

- ❖ **Smart Grids:** To ensure efficient management of water and energy consumption, Masdar City employs an extensive network of sensors installed throughout the urban landscape. These sensors meticulously track the consumption patterns of each resident, monitoring water and energy usage, and promptly detecting any anomalies such as faults or leaks. This wealth of data is transmitted to a centralized control center, where it undergoes comprehensive analysis. Here, any identified issues are swiftly addressed, ensuring optimal resource utilization and minimal wastage.

- Air Quality Control: Advanced monitoring devices are strategically positioned across residences, public spaces, halls, laboratories, and other key areas to regulate and maintain air quality standards.
- Public Awareness Initiatives: Large-scale digital displays are strategically placed in public areas, serving to inform and educate users about responsible energy and water consumption practices (Garg, 2011).

**Synthesis:**

Masdar City stands as a beacon of solar power and renewable energy, attracting top-tier specialists and experts while catering to the citizens' needs in an eco-conscious, health-conscious, and opulent manner. By seamlessly integrating traditional architectural elements with cutting-edge technology, the city significantly reduces perceived temperatures, even amidst the harsh desert environment. Despite formidable challenges such as water scarcity, sandstorms, and scorching temperatures, Masdar City is tangible proof that overcoming seemingly insurmountable obstacles is achievable.

### **Conclusion:**

In conclusion, the exploration of energy autonomy within smart urban environments highlights a transformative journey towards sustainable development and resilience.

This chapter has underscored the importance of integrating renewable energy sources, technological innovations, and community engagement to achieve energy self-sufficiency and environmental stewardship in cities worldwide.

Smart cities play a pivotal role in driving energy independence through advanced technologies like smart grids and energy management systems, optimizing energy generation, distribution, and consumption.

Community engagement is essential for the success of energy-autonomous quarters, promoting energy sharing, circular economy principles, and the integration of smart technologies for efficient energy use.

Policy frameworks are crucial for scaling up energy-autonomous quarters, providing incentives, regulatory support, and collaborative governance structures. By embracing decentralized energy production, leveraging smart technologies, fostering community participation, and enacting supportive policies, cities can lead the way towards a more resilient, inclusive, and sustainable urban future.

In essence, energy-autonomous quarters represent a visionary approach to sustainable urban development, driven by collaboration, innovation, and policy support. Through the collective efforts of stakeholders and the innovative spirit of smart cities, a smarter, a greener and more sustainable future can be realized for urban communities worldwide.



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## **CHAPTER III :**

# **Algeria's Unique Context for Smart Cities and Energy-Autonomous Quarters**

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1. Algeria's Urban Challenges: Understanding the Issues
2. Urban Planning Instruments in Algeria: Challenges and Limitations
3. Innovations for Smarter Cities in Algeria: What's Happening Now?
4. Smart City Initiatives in Algeria: What's Being Done?
5. Government Policies and Strategies: Addressing Energy Challenges in Algeria

**Introduction:**

In this chapter, we delve into Algeria's unique context for smart cities and energy-autonomous quarters, exploring the country's innovative approaches to urban development. The chapter is structured around several key themes that highlight Algeria's efforts to address urban challenges and leverage technology for sustainable growth.

The chapter begins by examining the concept of a ubiquitous city in Algeria, focusing on initiatives such as automated utility distribution and telecommunications enhancement that aim to streamline social and economic management processes. We explore the role of ICT networks and sensor technologies in shaping the technological environment of cities like Sidi Abdellah, where the Cyber Park serves as a hub for ICT companies and research activities.

Moving on, we discuss the role of ICTs in addressing pressing urban challenges such as traffic congestion, energy losses, and water network leakages, highlighting the importance of technology in enhancing urban efficiency and sustainability. We also delve into Algeria's internet evolution and its position in the global internet landscape, shedding light on the country's progress in telecommunications and digital connectivity.

Furthermore, we explore Algeria's legal framework for renewable energies and energy management, outlining key legislative measures that support the development of sustainable energy infrastructure. By examining Algeria's position in the world of renewable energies, we gain insights into the country's commitment to advancing clean energy technologies and reducing its carbon footprint.

Additionally, we discuss the role of urban intelligence and digital technologies in shaping smart cities in Algeria, emphasizing the importance of collaborative initiatives and stakeholder engagement in driving urban innovation. Through the deployment of mobile applications for urban services and the promotion of sustainable urban development practices, Algeria is paving the way for a more connected, efficient, and livable urban future.

We will discover how Algeria is leveraging innovation to create more vibrant, resilient, and connected urban environments for its citizens. Explore the initiatives, challenges, and opportunities that define Algeria's urban transformation and learn about the country's vision for sustainable and technologically advanced cities.

### **1. Algeria's Urban Challenges: Understanding the Issues:**

Algeria faces a multitude of urban challenges stemming from rapid population growth, unplanned urbanization, and inadequate infrastructure. With over 70% of the population residing in urban areas, cities are experiencing significant strain on resources and services. One of the primary challenges is housing shortages, leading to informal settlements and slums on the outskirts of major cities like Algiers and Oran. These informal settlements often lack access to basic amenities such as clean water, sanitation, and healthcare, exacerbating social inequalities and health risks (World Bank, 2018).

Moreover, rapid urbanization has put immense pressure on transportation networks, leading to congestion, air pollution, and inadequate public transport systems. Algerian cities struggle to provide efficient and sustainable transportation solutions, resulting in increased reliance on private vehicles and worsening traffic conditions. Additionally, urban sprawl and land use inefficiencies contribute to environmental degradation, loss of agricultural land, and fragmented urban development patterns (Bennadji et al., 2020).

Addressing Algeria's urban challenges requires comprehensive strategies that prioritize sustainable urban development, social inclusion, and infrastructure investment. By understanding the underlying issues and dynamics shaping urbanization in Algeria, policymakers can formulate evidence-based policies and interventions to create more livable, resilient, and equitable cities for all residents.

### **2. Urban Planning Instruments in Algeria: Challenges and Limitations:**

In 1990, many important legislative texts were introduced, particularly those related to land, planning, and urbanism, which were governed by Law 90-29 of 01-12-1990. The implementing decrees of this law established two urban planning instruments, the Urban Development Plan (PDAU) and the Land Use Plan (POS), which are still in effect today (Midjek. F, 2011).

Regrettably, urban planning and development instruments suffer from deficiencies that detach them from reality. The inefficacy of these instruments is further compounded by inadequate governance and bureaucratic delays. As a result, they have transformed from useful tools for urban management and regulation to mere tools for maintaining the status quo. Additionally, these instruments were created before the Rio Earth Summit in 1992, and as such, do not account for the principles and objectives of sustainable development, smart cities, or ICT (Djermoun. N, 2014).

### **3. Innovations for Smarter Cities in Algeria: What's Happening Now?**

#### **3.1 Internet Access in Algeria: Where We Stand?**

##### **3.1.1 A Brief of Algeria's Internet Evolution:**

In 1991, the cyber doors swung open for Algeria with the advent of the Internet, orchestrated by the Algerian Association of UNIX Users and in collaboration with the Algerian Scientists Association (ASA), forging a connection with Italy. Fast forward to 1993, when the CERIST (Research and Scientific Information Center), a public university entity, assumed the mantle as the sole gateway to Internet services, becoming the ISP (Internet Service Provider) authority.

The year 1995 marked a pivotal moment as the Internet surged in popularity, albeit to a limited audience. Then came the watershed moment of 1998, signaling the policymakers' intent to welcome private operators into the domain. By 1999, the floodgates truly opened for private competition, with March 2000 seeing a staggering 18 ISPs vying for prominence. Presently, over 80 enterprises boast accreditation, with the nod of approval granted by the Regulatory Authority for Post and Telecommunications (ARPT).

However, while Algeria's telecommunications sector undergoes profound metamorphosis, it lags significantly behind the global Internet evolution.(Doudi.L et al. in 2015).

### 3.1.2 Algeria's Position in the World of the Internet:

The following tables encapsulate Algeria's standing in terms of internet users' numbers and the percentage of internet users relative to the population. These tables meticulously pinpoint Algeria's precise ranking concerning both the quantity of internet users and the proportion of internet users in relation to the population. (Doudi.L et al., 2015)

| N°  | Pays           | Nb Internautes * 10 <sup>6</sup> |
|-----|----------------|----------------------------------|
| 1   | Etats Unis     | 166                              |
| 2   | Chine          | 68                               |
| 3   | Japon          | 62                               |
| 4   | France         | 41,8                             |
| 5   | France         | 30,4                             |
| 6   | Corée du Sud   | 24,38                            |
| 7   | France         | 23                               |
| 8   | Brésil         | 19,7                             |
| 9   | France         | 19,25                            |
| 10  | Russie         | 18                               |
| 29  | Afrique du Sud | 3,068                            |
| 56  | Egypte         | 0,6                              |
| 57  | Kenya          | 0,5                              |
| 63  | Tunisie        | 0,4                              |
| 64  | Maroc          | 0,4                              |
| 70  | Tanzanie       | 0,3                              |
| 71  | Algérie        | 0,3                              |
| 112 | Djibouti       | 0,001                            |

*Figure 27 Table Illustrating Ranking of Countries by number of Internet Users.*

| N°  | Pays           | %nb int/pop tot |
|-----|----------------|-----------------|
| 1   | Suède          | 68,54           |
| 2   | Islande        | 65              |
| 3   | Etats Unis     | 59,71           |
| 4   | Norvège        | 60              |
| 5   | Pays-Bas       | 57,5            |
| 6   | Hong Kong      | 55,56           |
| 7   | Australie      | 54,12           |
| 8   | France         | 53,29           |
| 9   | Suisse         | 52,74           |
| 19  | France         | 38,33           |
| 52  | Afrique du Sud | 7,04            |
| 64  | Tunisie        | 4,12            |
| 70  | Cap Vert       | 3,24            |
| 75  | Kenya          | 1,74            |
| 79  | Egypte         | 0,93            |
| 80  | Maroc          | 1,31            |
| 82  | Tanzanie       | 1,02            |
| 83  | Algérie        | 0,97            |
| 112 | Djibouti       | 0,22            |

*Figure 28 Table Illustrating Ranking of Countries by Percentage of Internet Users.*

### 3.1.3 Internet Service Providers:

In 2003, we identified around 80 Internet Service Providers (ISPs) in Algeria, since the opening of the internet sector in 1999. (Doudi.L et al., 2015).

| Pays               | Nombre de FAI |
|--------------------|---------------|
| Etats-Unis         | 7 800         |
| Canada             | 760           |
| Australie          | 718           |
| Royaume-Uni        | 400           |
| République Tchèque | 300           |
| Allemagne          | 200           |
| Afrique du Sud     | 150           |
| Italie             | 93            |
| Algérie            | 80            |
| Porto Rico         | 76            |
| Japon              | 73            |
| Kenya              | 65            |
| France             | 62            |
| Belgique           | 61            |
| Espagne            | 56            |
| Pays-Bas           | 52            |
| Mexique            | 51            |
| Brésil             | 50            |
| Egypte             | 50            |
| Turquie            | 50            |
| Suisse             | 44            |

*Figure 29 Table Illustrating Ranking of Countries with the Largest Number of ISPs.*

### **3.2 Communication Tech in Algeria: ICT**

Information and Communication Technology (ICT) plays a pivotal role in shaping Algeria's digital landscape, driving innovation, economic growth, and societal development. Algeria has witnessed significant advancements in ICT infrastructure, connectivity, and digital services in recent years, laying the foundation for a vibrant digital economy and knowledge-based society.

#### **3.2.1 ICT Infrastructure and Connectivity:**

Algeria has made substantial investments in ICT infrastructure to expand connectivity and improve access to digital services across the country. The deployment of fiber-optic networks, mobile broadband services, and satellite communications has significantly enhanced internet penetration and connectivity, particularly in urban areas. Mobile phone penetration is widespread, with mobile subscriptions exceeding the country's population, indicating the growing importance of mobile communication in Algerian society (ITU, 2020).

#### **3.2.2 Digital Services and E-Government:**

The Algerian government has launched various e-government initiatives to digitize public services, streamline administrative processes, and enhance government efficiency and transparency. Online platforms and digital services offer citizens convenient access to government information, public services, and administrative procedures, reducing bureaucracy and improving service delivery. E-government services such as online tax filing, electronic payments, and digital identity management facilitate citizen-government interactions and contribute to the modernization of public administration (World Bank, 2021).

**3.2.3 Digital Innovation and Entrepreneurship:**

Algeria's burgeoning digital ecosystem is fostering innovation, entrepreneurship, and job creation in the ICT sector. Tech startups and digital entrepreneurs are leveraging ICT to develop innovative solutions to local challenges, ranging from e-commerce platforms and mobile applications to digital payment systems and online marketplaces. Incubators, accelerators, and entrepreneurship programs are supporting the growth of the digital economy, nurturing talent, and fostering a culture of innovation and creativity (UNCTAD, 2019).

**3.2.4 Challenges and Opportunities:**

Despite the progress made, Algeria faces several challenges in fully harnessing the potential of ICT for socio-economic development. These challenges include limited access to ICT infrastructure in rural and remote areas, digital literacy gaps, regulatory barriers, and cybersecurity risks. Addressing these challenges requires concerted efforts from government, private sector, and civil society stakeholders to promote investment in ICT infrastructure, expand digital literacy programs, and strengthen cybersecurity measures (Freedom House, 2020).

In conclusion, ICT is a driving force for innovation, connectivity, and economic growth in Algeria, offering new opportunities for digital transformation and societal development. By embracing ICT, Algeria can unlock its full potential, foster inclusive growth, and build a prosperous future for its citizens.

**3.3 Digital Maps in Algeria: digitalisation of cadastre**

Abderrahmane Raouia, the Minister of Finance, underscored the potential short-term enhancements in public service delivery concerning land conservation and the streamlining of land title issuance through the digitization and computerization of land procedures.

In a noteworthy development, Cévital, the Algerian private conglomerate, has recently secured a pivotal public contract. Through its subsidiary Xerox, Cévital has been awarded the contract for the digitization of the cadastre, marking a significant milestone. According to Africa Intelligence reports, the General Directorate of National Domain (DGDN) allocated two out of three lots of the comprehensive initiative for digitizing national land data to CBS Xerox on February 14th. The commencement of the digitization process for the Algerian cadastral system, an initiative long deliberated, was set in motion in 2017 under the auspices of the DGDN.

This development assumes added significance given the intricate landscape of property disputes, some of which trace their origins back to the colonial era. The complexity of the issue is further underscored by the challenges faced by investors in navigating the process of acquiring industrial or agricultural land from the state, a process often fraught with obstacles. (Fadhel.H, 2018)

**3.4 ICT and Urban Planning: Current Trends in Algerian Cities:**

In the digital era we inhabit, the nexus between Information and Communication Technologies (ICT) and urban environments is more pertinent than ever. Terms such as 'connected city,' 'digital city,' or 'smart city' encapsulate the overarching aim: leveraging digital technologies for more efficient and sustainable urban development. The utilization of the term 'smart' inherently signifies the endeavor to harness digital capabilities towards the optimization of resources, democratic urban planning, and management. The overarching goal is to devise cities that are not only 'smarter' but also more functional, inclusive, resilient, and sustainable urban spaces (PFVT, 2018).

As instrumental tools, ICTs serve to address pressing urban challenges such as traffic congestion, energy losses, or water network leakages. In the context of Algeria, one of the primary objectives of the ICT development program was to address the challenges faced by Algerian cities and prepare the country for the establishment of digital and smart cities. In 2010, during a symposium themed 'Enhancing Urban Living through ICT,' the former CEO of Algeria Telecom, Moussa BENHAMADI, affirmed that 'Algeria is actively preparing for the establishment of smart digital cities,' and to materialize this vision, 'Algeria Telecom has allocated a substantial budget of approximately 100 billion dinars' (Bouhaddi.T et al., 2017)."

This concerted effort underscores the recognition of ICTs as catalysts for transformative urban development agendas, fostering enhanced livability, sustainability, and resilience within urban ecosystems.

**4. Smart City Initiatives in Algeria: What's Being Done?**

Algeria has begun to explore Smart City initiatives as a means to address urban challenges and harness technological advancements for sustainable development. This section delves into the ongoing efforts and initiatives in Algeria's journey towards becoming smarter and more efficient in urban management.

**4.1 Conferences and Meetings: Sharing Ideas**

Conferences and meetings serve as vital platforms for stakeholders to come together, exchange ideas, and collaborate on smart city initiatives. In Algeria, several conferences and meetings have been organized to discuss various aspects of smart city development:

**4.1.1 International and National Smart City Conferences:**

Algeria has organized conferences at the national level to discuss smart city development. These conferences bring together government officials, urban planners, industry experts, academics, and technology providers to share experiences, best practices, and challenges. Participants showcase their projects and identify opportunities for collaboration, making these events crucial forums for advancing smart city strategies.

- A seminar was hosted at Kasdi Merbah University Ouargla on April 8, 2015, featuring Professor MOHAMED CHERIET's discourse titled 'Technologies for Smart and

Sustainable Cities.' Professor Mohamed Cheriet underscored that 'The concept of smart and sustainable cities transcends mere speculative fiction, embodying a tangible reality embraced by numerous technologically advanced nations, including select Arab states in Asia, such as the United Arab Emirates.' He further articulated that 'Algeria, endowed with substantial potentialities, stands poised to emerge as a frontrunner in this domain' (ALGERIE-FOCUS, 2017).

#### **4.1.2 International Workshops and Seminars:**

- The international conference 'Smart Cities Global Technology & Investment Summit' held on June 27 and 28, 2018, at the International Conference Center in Algiers.

This summit was organized by the Algiers Province in collaboration with the British consultancy firm TMT Finance (Le Courrier d'Algérie, 2018). More than 40 countries and 15 world-renowned institutions in the technological domain, along with over 150 international speakers and 4,000 national and international delegates, including startup professionals, executives of major companies, and leaders in smart city investment worldwide, participated in this seminar to share their experiences in designing smart cities (DZEntreprise, 2018).

The objective of this event was to foster international partnerships and exchange knowledge regarding the development of sustainable cities and High-Tech investment, as well as to find solutions to three main problems: the lack of visibility of new technologies' usage in Algeria, the Algerian industry's dependence on foreign technology manufacturers, and the lack of confidence among Algerian industrialists, both private and public, in the quality of Algerian products. Through workshops, conferences, and various activities, national and international experts attempted to provide initial responses to these issues and initiate projects that could practically pave the way for technological development in contemporary urban settings in Algiers.

As the former Wali of Algiers, Abdelkader Zoukh, declared during a press conference, the main objective of this international seminar is to 'create a favorable climate for developing and promoting startups and integrating university graduates, who are key to creating smart cities and city development' (Khaled, 2018). The summit's program on the first day at the CIC mainly featured several keynotes presented by leaders in ICT, including the main figure

#### **4.1.3 Public-Private Partnerships (PPPs) Forums:**

PPPs forums bring together government agencies, private sector companies, and civil society organizations to explore opportunities for collaboration in smart city projects. These forums facilitate dialogue, networking, and partnership building among stakeholders, fostering innovation and investment in smart city infrastructure and services (World Bank Group, 2018).

#### **4.1.4 Academic Conferences and Research Symposia:**

Universities and research institutions in Algeria organize academic conferences and research symposia focused on smart city themes, such as urban innovation, sustainable development, and digital transformation. These events provide platforms for scholars,

researchers, and students to present their findings, exchange knowledge, and collaborate on interdisciplinary research projects related to smart cities (University of Algiers, 2021).

## **4.2 Apps in Action: Using Technology for Solutions**

In the realm of smart city initiatives, the deployment of mobile applications (apps) stands out as a transformative tool for enhancing citizen engagement, service delivery, and urban management. Algerian cities are increasingly leveraging apps to address various urban challenges and deliver innovative solutions tailored to the needs of residents. This subsection explores the role of apps in driving positive change and improving urban quality of life in Algeria.

### **4.2.1 Mobile Apps for Urban Services:**

One area where apps are making a significant impact is in delivering urban services more efficiently and conveniently to residents. Mobile apps enable citizens to access essential services such as public transportation. Algeria already uses public transportation apps like "Algeria Bus" to provide real-time information on bus routes, schedules, and fares, empowering commuters to plan their journeys more effectively and reduce wait times (Mouhouche, 2019).

### **4.2.2 Smart Bus Shelters:**

SPA AD Display, a prominent outdoor communication firm in Algeria, has undertaken the digital revolution of Algiers' bus shelter network. Pioneering the city's digitalization, AD Display initiated the transformation in 2013 by introducing 50m<sup>2</sup> LED screens, followed by 25m<sup>2</sup> displays, and eventually deploying 30 digital totems, each measuring 2m<sup>2</sup>, across the iM@rket Network (Algeria's digital network).

Operating through an intelligent remote-controlled platform fueled by qualitative data, the iM@rket Network offers a modern medium that leverages cutting-edge technology to enhance audience engagement and effectively target demographics (ALGERIE-FOCUS, 2016).

Beyond the installation of outdoor displays, AD Display introduced the first digital bus shelter network in Africa, spanning across the Maghreb region and the Arab world. This expansion marked the company's foray into smart urban infrastructure. Positioned at the vanguard of contemporary technological advancements, AD Display's CEO, Mr. Mourad Hadj-Saïd, articulated the company's vision: *"Our objective is to enable the city to engage with its citizens through dynamic mediums", emphasizing the company's aspiration to establish digital urban furniture "to propel towards the Smart City". In essence, progressing towards, "the connected and intelligent city".*

Beginning in 2016, AD Display embarked on the strategic installation of digital bus shelters at prime locations across Algiers, such as Audin Square, El-Mouradia, and Hydra. These sites were strategically chosen within the capital's bustling commercial zones, frequented daily by residents and visitors alike.

The innovative bus shelters feature dynamic 84-inch Ultra HD 4K touchscreen displays, fully connected and available in various dimensions. Equipped with internet connectivity, LED screens, and a plethora of other features, these connected bus shelters serve as a contemporary platform for local communication.

According to Hadj-Saïd, this modern infrastructure is poised to disseminate general interest messages, advertisements, vital information, and city updates effectively. He emphasized that AD Display's commitment to manufacturing 60% of the furniture in Algeria ensures that each piece complements the architectural essence of its respective city. 'Our design philosophy,' he noted, 'is centered on leveraging the unique characteristics of each city to promote socio-economic development and enhance citizen comfort over the long term' (Mouloudj, 2016).



*Figure 30 Connected Bus Shelters;*

*source: (Algerie 360°;04;2024)*

#### **4.2.3 Fiber Optics Infrastructure:**

Algeria has successfully deployed over 140,000 kilometers of fiber optic cable as part of its national strategy to interconnect all the states to a high-speed telecommunications and internet network. This extensive fiber optic network facilitates the delivery of various services including television, e-education, e-commerce, e-administration, and e-health (ALGERIE-PRESSE-SERVICE, 2018).

#### **4.3 Smart City Projects in Algeria: Examples and Progress**

In recent years, Algeria has embarked on several smart city projects across different regions, aiming to modernize infrastructure, enhance service delivery, and promote economic growth. Here are some examples of smart city projects in Algeria :

##### **4.3.1 Sidi Abdellah: A Look at Sustainable Urban Living**

- **Overview of the New Urban Development:**

The New City of Sidi Abdellah, strategically located 25 kilometers west of Algiers, constitutes an integral part of the Algiers Sahel region, bordered by the Mitidja plain to the south and the coastal plain to the north (Souag and Dorbhan, 2005). Covering an expansive

area of 7,000 hectares, with 4,000 hectares allocated for conservation and 3,000 hectares earmarked for urbanization, it encompasses the municipalities of Mahelma, Rahmania, Douera, Souidania, and a portion of Zéralda. Upon full realization, this development is poised to accommodate a population of 280,000 residents and generate approximately 85,000 employment opportunities (vnasa, 2016).

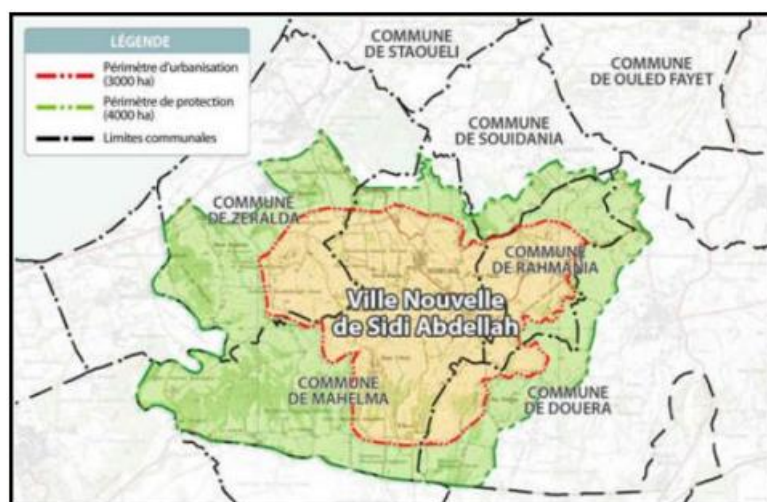


*Figure 31 The situation of the New Town of Sidi Abdellah.*

*Source (slideplayer, 2015)*

The New City of Sidi Abdellah stands as a burgeoning urban hub in Algiers, with its primary role being to foster competitiveness, innovation, and excellence. It is envisioned to catalyze rebalancing the metropolitan growth of Algiers (vnasa, 2016). Positioned to actively contribute to the economic dynamics of the metropolitan area, it aims to address all complementary dimensions—economic, social, and residential—adjacent to those of Algiers (IKENOUNE and AKIL, 2015).

Comprising 27 urban clusters, the city plans to accommodate nearly 54,000 housing units through various development projects. Beyond its urban core, Sidi Abdellah boasts several specialized sectors, including pharmaceutical and biotechnological (148 hectares), healthcare (51 hectares), and recreational and sports facilities (732 hectares) (CIAF, 2016).

- **The Approach of the New City Project:**

The development of Sidi Abdellah aligns with urban and territorial planning policies aimed at mitigating the human over-concentration in the capital, which poses challenges for urban management (e.g., infrastructure, facilities, transportation networks). It also seeks to curtail urban sprawl, preserving valuable agricultural lands and the environment. The government envisions Sidi Abdellah as a smart and integrated city, setting a precedent for future new city developments and urban revitalization projects (ELMOUDJAHID, 2016).

**Key directives guiding the development include:**

- ❖ Preservation of resources.
- ❖ Development of public transportation and pedestrian-friendly infrastructures
- ❖ Cultivating a High-Quality Living Environment: The design ethos of the New City emphasizes greenery, with approximately 25% of its area dedicated to lush green spaces, while activity zones are strategically situated on the outskirts, fostering an ambiance of excellence (AROUMOUGOM, 2003).

- **Urban Composition of Sidi Abdellah:**

**a) Residential Zones:** Among the 36 districts within the city, 23 are designated residential areas.

**b) Commercial and Administrative Hub:** At the city's core lies a bustling center comprising essential functions such as vibrant commercial districts, essential public services, and administrative headquarters.

**c) Advanced Industry and Research Clusters:** Cutting-edge industries are concentrated within specialized precincts, including the Cinéparc and Technoparc, pharmaceutical and biotech hubs, ICT enclave, cyber park, and healthcare precinct.

**d) Key Infrastructure:** Encompassing a diverse range of amenities like a theme park, university precinct, security hub, and land reserves.

**e) Green Spaces:** Anchored by the Central Park at its heart, the city boasts a thoughtfully planned green network, weaving through local parks and verdant corridors, extending citywide and connecting seamlessly to the coastline through the Protection Park (Epic-VNSA, 2017).



Figure 32 New city Sidi Adellah plan; Source (slideplayer, 2015)

The location of Sidi Abdellah is strategically positioned concerning transportation infrastructure. It benefits from proximity to the southern ring road connecting Boudouaou and Zéralda, as well as the ongoing development of the Zéralda-Sidi Abdellah-Birtouta railway link. Additionally, the area is encircled by two peripheral roads facilitating connectivity between the Zéralda-Dar el Beïda and Zéralda-Boudouaou routes (vnsa, 2016).



Figure 33 Map illustrating the Accessibility of the City of Sidi Abdellah.

Source (slideplayer, 2015)

## • The Smart City Initiative in Sidi Abdellah:

Sidi Abdellah's vision for urban development encompasses ambitious projects like the Cyber Park, Researcher's City, Medical City, alongside innovative structures such as smart buildings and futuristic residential complexes, all poised to propel the city into the future. In contrast to cities studied previously, there's a noticeable gap in urban intelligence initiatives. In the following sections, we outline the foundational methods and tools available in Sidi Abdellah, serving as crucial first steps towards establishing a smart city in Algeria:

- **Comprehensive Fiber Optic Connectivity:** Sidi Abdellah boasts a fully connected infrastructure with fiber optic networks, providing high-speed access to telephone and internet services, complemented by widespread public Wi-Fi coverage.
- **Advanced Access Control Systems:** Residents benefit from secure and efficient access to facilities through digital authentication methods like magnetic cards or fingerprint scanning.
- **Sustainable Public Lighting:** The city prioritizes energy efficiency with solar-powered public lighting equipped with motion sensors, effectively reducing energy consumption and costs (DKNews, 2016).
- **Renewable Energy Promotion:** Sidi Abdellah is committed to harnessing renewable energy sources like photovoltaic and wind power, supported by the establishment of dedicated energy hubs.
- **Automated Utility Distribution:** The city implements automated distribution systems for utilities, integrating advanced technologies and detailed Geographic Information System (GIS) mapping for efficient management.

- Telecommunications Enhancement: Significant investments have been made to upgrade telecommunications infrastructure, including the expansion of broadband networks to ensure high-quality service delivery through backbone network extensions.
- In the field of telecommunications, plans are underway to establish ubiquitous communication networks (ICT networks) (MANSOUR, 2017).
- Sidi Abdellah as a Ubiquitous City (U-City):

The U-City project aims to streamline social and economic management processes and enhance urban comfort. This principle aligns seamlessly with the technological environment envisioned for Sidi Abdellah, characterized by electronics, computing, sciences, and ICT.

The concept of a ubiquitous city in Algeria is technically supported by Broadband Convergence Networks (BCN) and Ubiquitous Sensor Networks (USN) (Epic-VNSA, 2017).

- The Cyber Park:

Sidi Abdellah's Cyber Park serves as a vibrant hub for ICT companies, fostering collaboration among researchers, entrepreneurs, and project developers. It features a center for ICT studies and research, (comprising research and development laboratories, testing facilities, and technology transfer platforms). Additionally, it includes two towers ( a business center and a corporate hotel ) interconnected by a spacious hall. In addition to office spaces, the park encompasses two large open spaces and a 9800 m<sup>2</sup> business incubator tailored to support project developers and startups. This incubator includes( seven rooms dedicated to startups, three rooms allocated for training purposes, and three rooms provided for Microsoft, Cisco, and BIM companies ).(LOUNES et al., 2010).



*Figure 34 Cyber Park*

#### **4.3.2 Algiers Smart City: Building Intelligence in Urban Spaces**

Algiers, Smart City" is an ongoing project managed by the Algiers Governorate in Algeria. Its roadmap, established two years ago, aims to enhance citizens' quality of life by

leveraging local stakeholders in the new technologies sector and fostering the creation of innovative startups (Ferhat and Racim, 2018). The planning for this initiative commenced on June 1, 2017, with a partnership call issued to various Smart City stakeholders, culminating in the execution of a concrete action plan.

The primary objective of the Algiers Smart City project is to optimize city management. This requires the direct involvement of various stakeholders, including transportation, energy, urban planning, water, security, health, and logistics services. The integration and exploitation of information technologies are central to Smart City design, encompassing aspects such as data acquisition, transmission, management, and city activity optimization, applied to various Smart City components. A crucial aspect of Smart City design involves leveraging city databases to optimize data sharing among different city departments and residents (Wilaya-d'alger, 2017).

Jonathan Trent, director of the OMEGA Global Initiative and a researcher at NASA, emphasized that Algeria is well-positioned to develop its Smart City and can draw valuable lessons from its unique experiences rather than replicating models from developed countries (Ferhat and Racim, 2018).

In efforts to better understand the Smart City concept, public institution officials have initiated project preparation by organizing several seminars and symposiums. Algiers hosted the World Summit on Smart City Technology and Investment, with the primary aim of highlighting global and regional strategies for smart city growth (Meziane, 2017). The Algiers Smart City Project team has identified priorities, challenges, and stakes, including:

- Accelerating exchanges between Algiers' ecosystem and the global technology ecosystem.
  - Optimizing synergies between global technology companies and local technology enterprises.
  - Strengthening trust among local enterprises.
- The Alger Smart City initiative is centered around:
    - ✓ Fostering the growth of startups and bolstering local incubators/accelerators across engineering, business, partnerships, and financing.
    - ✓ Strengthening connections between Algiers' technological ecosystem and the local, regional, and global technology and business communities.
    - ✓ Serving as a driving force for diverse initiatives in Algiers, uniting various stakeholders of the Alger Smart City project, including technology, business, government, and more.
      - ✚ Promptly initiating key projects, including a large-scale experimental laboratory for Alger Smart City and a technological innovation hub.



*Figure 35 Map of the Experimental Laboratory and Technological Innovation Hub.*

*Source: (Experimental Large-Scale Laboratory and Technological Innovations Hub, 2018)*

## **5. Government Policies and Strategies: Addressing Energy Challenges in Algeria**

Algeria faces significant energy challenges, including the need to meet growing demand, reduce energy consumption, and transition towards sustainable energy sources. This section examines the government policies and strategies aimed at addressing these challenges, focusing on the legal framework, energy efficiency programs, institutional organization, and the role of key entities such as APRUE and the National Fund for Energy Management (FNME).

### **5.1 Legal Framework: Understanding the Corpus Juridique**

The enactment of a supportive legal framework for the advancement of renewable energies and the development of corresponding infrastructure is delineated through several key measures:

Acknowledging the escalating significance of renewable energies and their attendant ramifications, Algeria has integrated their progression into its energy strategy via the adoption of conducive legislative frameworks.

The advancement of renewable energies is guided by an array of legislative enactments:

- ❖ Law No. 99-09 of July 28, 1999, concerning energy management.
- ❖ Law No. 02-01 of February 5, 2002, concerning electricity and the public distribution of gas by pipelines.
- ❖ Law No. 04-09 of August 14, 2004, concerning the promotion of renewable energies within the framework of sustainable development.

- ❖ Law No. 11-11 of July 18, 2011: Supplementary Finance Law for 2011 raised the level of the oil levy, which primarily funds the National Fund for Renewable Energies and Cogeneration (FNER), from 0.5% to 1% and extended its scope to cogeneration facilities.
- ❖ Executive Decree No. 11-423 of December 8, 2011, establishing the operating procedures of the special allocation account No. 302-131 entitled "National Fund for Renewable Energies and Cogeneration."
- ❖ Executive Decree No. 13-218 of June 2013, setting the conditions for granting incentives for electricity production diversification costs.
- ❖ Executive Decree No. 13-424 of December 18, 2013, amending and supplementing Executive Decree No. 05-495 of December 26, 2005, relating to energy audits of large energy-consuming establishments.
- ❖ Ministerial Orders of February 2, 2014, establishing guaranteed purchase prices for electricity production from installations using photovoltaic technology and the conditions for their application.
- ❖ Ministerial Orders of February 2, 2014, establishing guaranteed purchase prices for electricity production from installations using wind energy and the conditions for their application.

## **5.2 Energy Efficiency Program in Algeria: A Comprehensive Overview**

Algeria adopted an ambitious program for renewable energies and energy efficiency in February 2011, with the undivided attention of the government directed towards the success of this program, based on a green strategy outlined for the horizon of 2030.

### **5.2.1 Institutional Organization:**

The framework for the national energy efficiency policy has been established within the scope of Law No. 99-09 of July 28, 1999, concerning energy management. The envisaged instruments include:

- The Agency for the Promotion and Rationalization of Energy Use (APRUE).
- The National Energy Management Fund (FNME).
- The Intersectoral Energy Management Committee (CIME).
- The National Program for Energy Efficiency.

### **5.2.2 Legal and Regulatory Instruments:**

The legislation regarding energy management reflects the efforts of the Public Authorities, particularly in legislative and regulatory domains. The objective is to bolster this framework through the implementation of regulations, notably addressing:

- Thermal regulations for new buildings.

- Energy audits for major energy-consuming establishments.
- Energy efficiency classification of household appliances.
- Modalities for organizing and implementing energy efficiency controls.
- Energy labeling.

### **5.3 The Role of APRUE:**

#### **Introduction to APRUE:**

Established by presidential decree in 1985 and operating under the Ministry of Energy and Mines, the National Agency for the Promotion and Rationalization of Energy Use (APRUE) is a public industrial and commercial institution. Its core mandate revolves around implementing the national energy management policy, primarily by fostering energy efficiency.

 Aligned with the provisions of Law No. 99-09 issued on July 28, 1999, APRUE is entrusted with the following key responsibilities:

- Propagating energy-saving practices across diverse sectors.
- Engaging stakeholders to address challenges and opportunities concerning energy efficiency.
- Facilitating partnerships for the development of energy efficiency projects and attracting potential investors.
- Contributing to the sustainable advancement of energy efficiency initiatives.
- Enhancing the skills and capabilities of stakeholders involved in the energy sector.

#### **ENERGY EFFICIENCY PROGRAMS:**

- Top-Industry Program.
- Eco-Lighting Program.
- Prop-Air Program.
- Eco-Building Program.
- Alsole Program.

## **Conclusion**

In conclusion, this chapter has provided a comprehensive overview of Algeria's unique context for smart cities and energy-autonomous quarters, highlighting the country's proactive approach to urban development and technological innovation. By exploring key themes such as ubiquitous cities, ICT networks, renewable energies, and urban intelligence, we have gained valuable insights into Algeria's efforts to address urban challenges and create more sustainable, efficient, and connected urban environments.

Through initiatives like the Algiers Smart City project and the digitization of the cadastre, Algeria is leveraging technology to optimize city management, enhance public services, and foster economic growth. The country's focus on ICTs, mobile applications, and collaborative partnerships underscores its commitment to driving urban innovation and improving the quality of life for its citizens.

Algeria's progress in internet evolution, renewable energies, and smart city development reflects its vision for a more technologically advanced and environmentally conscious urban landscape. By embracing digital transformation, sustainable energy practices, and inclusive urban planning, Algeria is laying the foundation for a future where cities are not only smarter but also more resilient, inclusive, and sustainable.

As Algeria continues on its journey towards smarter cities and energy-autonomous quarters, it is essential to prioritize collaboration, innovation, and stakeholder engagement to ensure the successful implementation of smart city initiatives. By building on the momentum generated by current projects and initiatives, Algeria can further enhance its urban environments, improve quality of life, and create cities that are truly smart, sustainable, and responsive to the needs of their residents.

In closing, Algeria's commitment to smart city development and sustainable urban planning sets a positive example for other countries seeking to harness the power of technology and innovation for the benefit of their cities and communities. By embracing a holistic approach to urban development and leveraging the latest advancements in technology, Algeria is paving the way for a more connected, efficient, and livable urban future.



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## **CHAPTER IV:**

# **Into the Heart of Transformation: Analysing El-Hassania Quarter for Energy-Autonomous Solutions**

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1. Territorial and Urban Assessment
2. Analysis of Renewable Energy at El-Hassania Using SAM (System Advisor Model)
3. Urban Planning Perspectives in Chlef: A Conversation with the Experts
4. Case Study Analysis and Survey Results Interpretation
5. Evaluation of El-Hassania Neighborhood According to GIFFINGER Criteria
6. Potentials and Weaknesses Across Multiple Scales

### **Introduction:**

This chapter embarks on an expansive exploration of the factors that are instrumental in shaping the future trajectory of Chlef, with a dedicated focus on the El-Hassania Quarter and its potential for adopting energy-autonomous solutions. It unfolds a meticulously structured journey that begins with the inception of data collection and the design of a comprehensive questionnaire aimed at evaluating the feasibility of transitioning El-Hassania into an energy-autonomous smart district.

Utilizing the powerful analytical capabilities of SPSS (Statistical Package for the Social Sciences), the chapter conducts thorough data analysis encompassing univariate, bivariate, and multivariate methodologies to extract nuanced insights from the responses provided by residents.

Moreover, the chapter progresses to delve into an in-depth exploration of the solar energy potential within the El-Hassania Quarter using SAM (System Advisor Model). This phase offers a robust platform for modeling and assessing the performance and financial viability of solar photovoltaic systems, thus providing a detailed roadmap for integrating renewable energy sources into urban planning.

Throughout this analytical journey, a strong emphasis is placed on fostering community engagement and forging collaborative partnerships among governmental bodies, private sectors, and various stakeholders. This collaborative effort is essential for establishing a cohesive vision and implementing a resilient framework necessary to propel Chlef towards a sustainable and prosperous future as a smart city.

Additionally, the chapter undertakes a comprehensive evaluation of Chlef based on the Giffinger criteria, which serves as a structured framework for assessing its potential as a smart city. Key dimensions such as smart governance, citizen engagement, economic vitality, mobility infrastructure, and environmental sustainability are meticulously examined to gauge the city's readiness and potential for smart urban development.

Finally, the chapter concludes with a detailed and insightful table that delineates the identified strengths and weaknesses specific to the El-Hassania Quarter. These findings serve as invaluable guidelines for informing strategic decisions related to sustainable development initiatives and infrastructure upgrades within the region, thereby contributing to the overall resilience and livability of Chlef.

## **1. Territorial and Urban Assessment:**

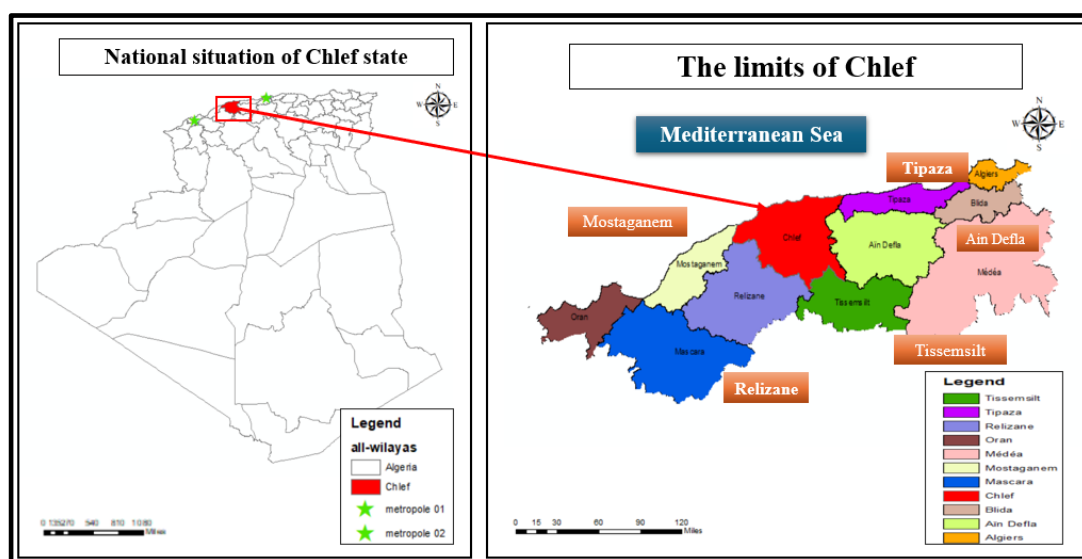
Understanding territorial and urban dynamics interplay is essential for effective urban planning and development. By analyzing the broader territorial context alongside specific urban characteristics, stakeholders can identify opportunities for sustainable growth and infrastructure enhancements to create vibrant and resilient urban environments.

### **1.1 Territorial Scale:**

Analyzing the territorial scale offers insights into the broader geographical and administrative context for urban development. By examining boundaries, natural assets, and population distribution, stakeholders can plan strategically for sustainable growth and resilience.

#### **1.1.1 Overview of the state of Chlef:**

The state of Chlef is an Algerian territorial collectivity located in northern Algeria, 200 km southwest of Algiers and 210 km northeast of Oran benefiting from the passage of transport links and infrastructures. The territory of the wilaya spans an area of 4,077 km<sup>2</sup> and features a coastline of more than 120 km.



*Map 1 Map of location and boundaries of Chlef state*

*Source: Created by the author*

It is bordered:

- to the north by the Mediterranean Sea,
- to the south by the Wilaya of Tissemsilt,
- to the east by Ain Defla and Tipaza,
- to the west by the Wilayas of Mostaganem and Relizane.

The state of Chlef consists of 13 Daïras and 28 Communes, spanning an area of 4,077 km<sup>2</sup>. With an estimated population of 1,356,151 inhabitants, the region has a population density of 333 inhabitants per km<sup>2</sup>.

### **1.1.2 Natural Potential:**

**Forest Heritage:** The Wilaya of Chlef boasts a significant forest heritage, covering an area of 99,310 hectares, which constitutes 21% of the total area of the Wilaya. The forested area is divided into four districts: Chlef (18,839 ha), Dahra West (30,125 ha), Dahra Center (26,294 ha), and Dahra East (24,050 ha). The predominant tree species are Aleppo pine and Holm oak.

**Nurseries:** This sector includes four nurseries, totaling 26.5 hectares. This year, the production is estimated at 18,420 units of alignment trees, 279,035 units of forage trees, and 948,694 units of forest trees.

**Forest Production:** This year's forest production reached 3,920 m<sup>3</sup> of construction timber, 4,420 m<sup>3</sup> of firewood, 10,480 units of beams, and 58,190 units of poles.

### **1.1.3 Hydraulics:**

The Wilaya of Chlef has seen significant improvements in hydraulic indicators from 1999 to 2021:

- The potable water connection rate increased from 62% to 98%, and the sanitation connection rate rose from 60% to 90%.
- Water allocation per capita improved from 70 liters/day in 1999 to 180 liters/day in 2021, largely due to the operationalization of the Ténès seawater desalination plant, with a production capacity of 200,000 m<sup>3</sup>/day, meeting the needs of 31 communes and approximately 1,100,000 people (98% of the Wilaya's population).

The Chelif River stands as the primary waterway, flowing through the wilaya from east to west, and it is intersected by two significant dams: Oued Fodda and Sidi Yakoub; the Wilaya contains two ports.



*Figure 36 Sidi Yakoub Dam; Chlef*



*Figure 37 Sidi Yakoub Dam; Chlef*

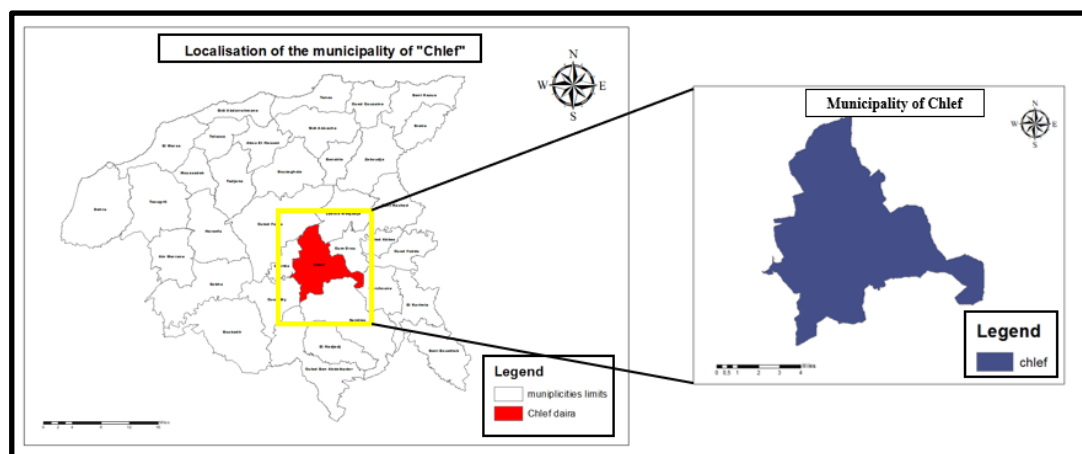
- The ICT infrastructure encompasses various types of connections: ADSL, 4G LTE, WIFI, and WI MAX, providing speeds of 1, 2, 4, 8, and 20 Mbps for ADSL, and up to 100 Mbps for 4G. With an internet subscription rate of 80%, the existing fiber optic network (FTTx), which is planned to be upgraded to FTTH, offers the potential for achieving ultra-high-speed connectivity in the future.
- Renewable Energies: As part of the state's adopted energy transition strategy, utilizing renewable energies at the local community level, the Chlef province has powered several primary schools with solar energy. Additionally, for mosques, three locations have been selected in the municipalities of Chlef, Kadiria, and Chatia for connection, with the technical connection process currently under study.(Monography Chlef;2020)

## **1.2 Within the municipality of "Chlef":**

Delving into the specific characteristics within the municipality of Chlef provides a detailed understanding of the urban fabric and administrative structure of this region. By examining the internal organization, accessibility, and key features of Chlef, stakeholders can identify opportunities for infrastructure development and urban enhancement to support the well-being and prosperity of its residents.

### **1.2.1 Overview:**

The municipality of Chlef is bordered by Ouled Fares and Labiod Medjadja to the north, Chettia to the west, Oued Sly to the southwest, Sendjas to the south, Harchoun to the southeast, and Oum Drou to the east. The city serves as its central hub at the heart of the municipality.



*Map 2 Map of location and boundaries of the municipality of Chlef*

*Source: Created by the author*

### **1.2.2 Administrative Identity:**

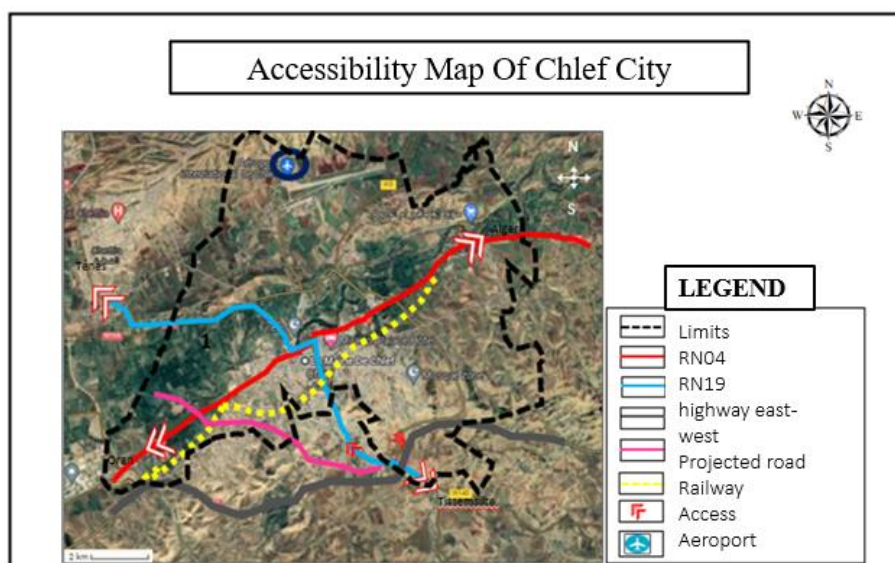
The municipality includes one central agglomeration (Chlef) and eight secondary agglomerations (Chegga, Cheraiet, Mouafkia, Benhattab, Kefafsa, Mekhatria Ramlia, El Aziez Brancia, Chouiet, and El Ouabed), as well as several scattered areas.

### **1.2.3 Accessibility of Chlef city**

Chlef is served by the RN04 highway, which connects the two major cities of Algiers and Oran, and by the less significant RN19, which links the city of Ténès to other Wilayas such as Tissemsilt and Tiaret. The city is also traversed by significant infrastructure, including the East-West Highway and a railway line.

Its geographical location at the heart of a strategic region, along with the presence of major transportation routes, provides Chlef with extensive territorial access and reinforces its role as a pivotal hub for East-West exchanges.

Additionally, Chlef is served by an airport located approximately 10 km north of the city. Chlef Airport is an international civil airport that serves the city and its surrounding region.



*Map 3 Accessibility Map of Chlef City*

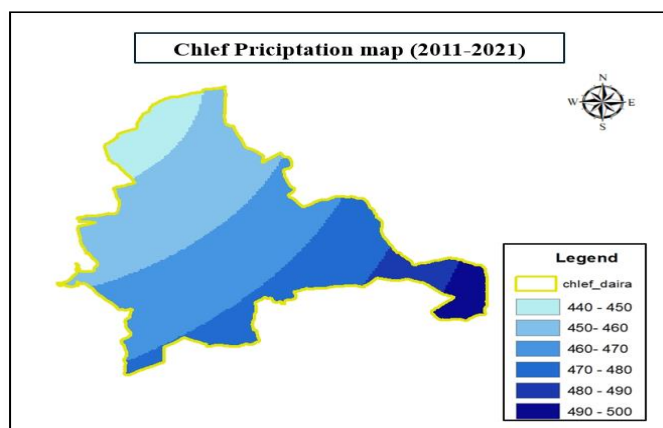
*Source: Created by the author*

### **1.2.4 Climatology:**

The climate in Chlef is classified as Mediterranean sub-humid. Interannually, it is generally described as semi-arid, characterized by sweltering summers and cold, rainy winters.

#### **1.2.4.1 Precipitation:**

Chlef experiences moderate and balanced precipitation, with a daily precipitation probability exceeding 50 mm and a minimum precipitation range of less than 2-10 mm.



*Map 4 preception map of chlef municipality*

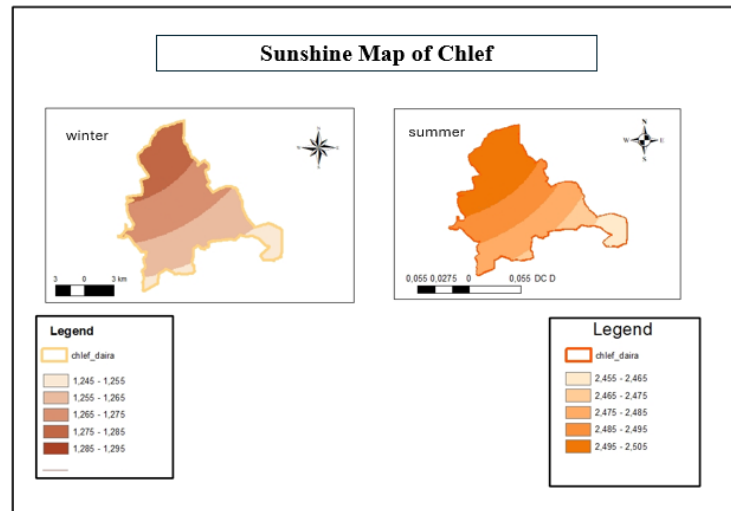
*Source: Created by the author*

#### **1.2.4.2 SunLight:**

In the region of Chlef, the month with the highest number of daily sunlight hours is July, with an average duration of approximately 12.52 hours per day. In total, there are about 388.06 hours of sunlight during this period.

On average, Chlef experiences the fewest daily sunlight hours in January. The total duration of sunlight during this period is recorded as 193.43 hours, with an average of about 6.24 hours per day.

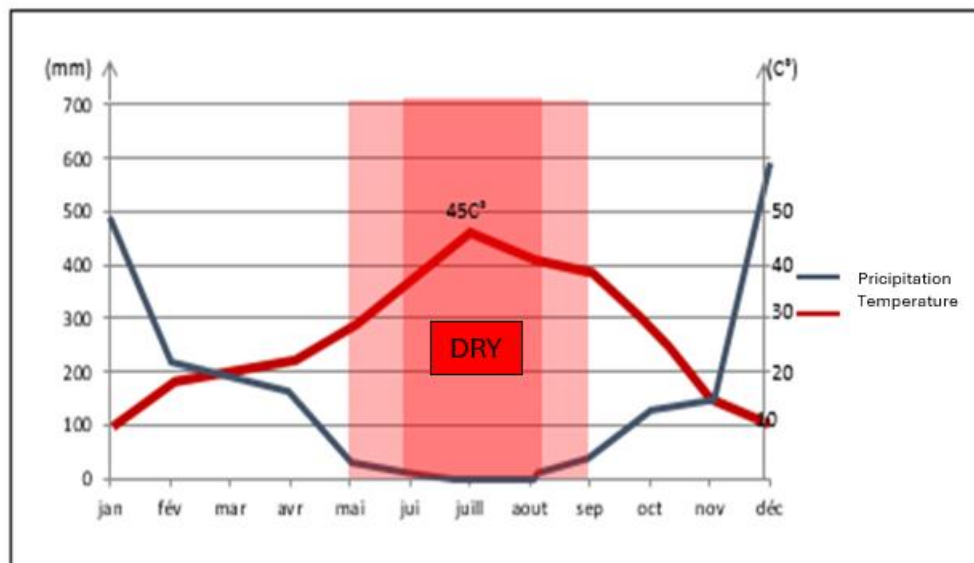
Throughout the year, Chlef benefits from approximately 3367.97 hours of sunlight. The average monthly duration of sunlight is estimated to be around 110.58 hours.



*Map 5 Map represents the sunlight data in Chlef*

*Source:by author*

**Temperature:** The temperature in Chlef is very high in summer and low in winter, with a daily average maximum temperature exceeding 34°C.



*Graph 1 Temperature and Precipitation Data*

*Source: PTAW and processed by the author*

*Table 1 Temperature and Precipitation Data*

| Mois  | Jan | feb | mar | April | mai | june | July | Aug | sep | oct | nov | Dec |
|-------|-----|-----|-----|-------|-----|------|------|-----|-----|-----|-----|-----|
| T(C°) | 10  | 18  | 20  | 22    | 28  | 35   | 45   | 43  | 38  | 30  | 15  | 10  |
| P(mm) | 50  | 23  | 20  | 16    | 4   | 0    | 0    | 0   | 4   | 15  | 20  | 50  |

*Source: PTAW and processed by the author*

### 1.2.4.3 Wind:

The average wind speed in Chlef shows moderate seasonal variation throughout the year, with a maximum speed of 38 km/h and a minimum speed of 12 km/h. The prevailing winds in the Chlef region generally come from the northwest, southwest, and northeast. During our trial period, the dominant wind directions were north-northeast, north, and south.

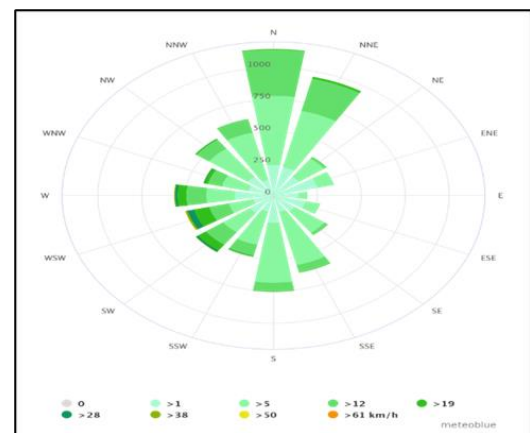


*Figure 38 Wind Rose of Chlef*

*Source: Climate Chlef - meteoblue*

### 1.2.5 Topography:

The topography of the city of Chlef is characterized by a mix of mountainous terrain, plains, intermontane valleys, and coastal areas. The distribution, organization, alignment, and arrangement of these features are determined and guided by the structuring of the Tell Atlas Mountain range.

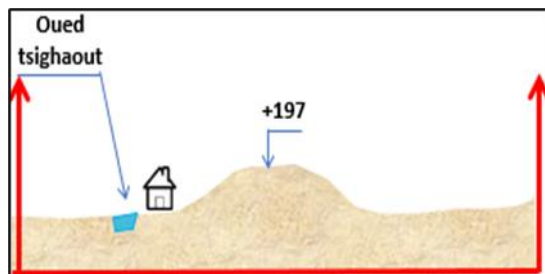


*Figure 40 profile AA'*

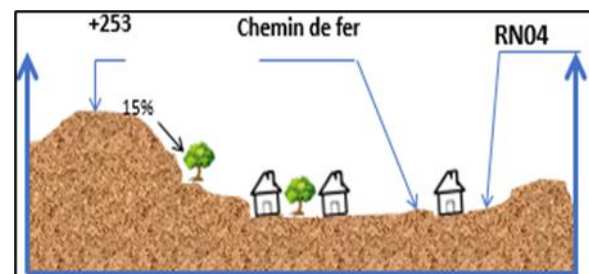
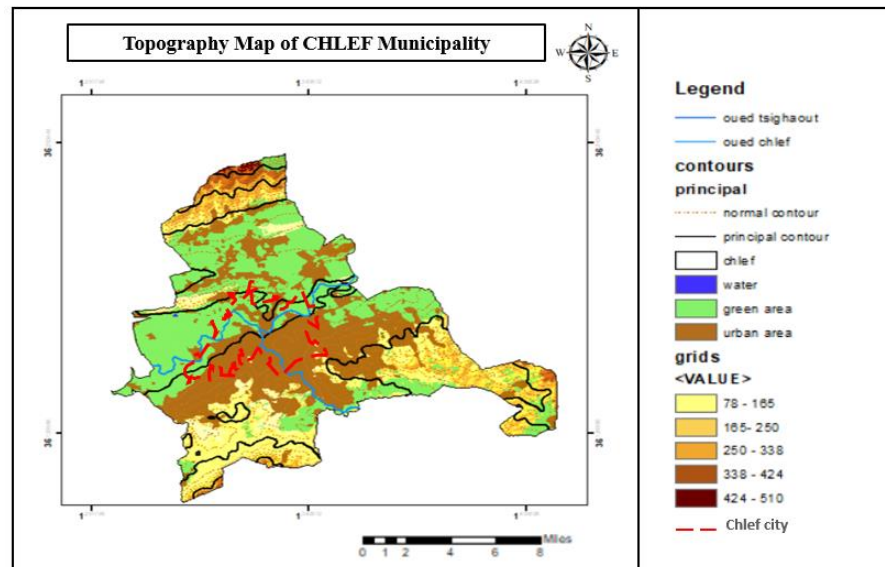


*Figure 39 profile BB'*



*Map 6 Topography Map of CHELF Municipality*

*Source:by author*

### **1.2.6 Morphology and Hydrology:**

Chlef is situated within a geographical basin: the Cheliff Plain, nestled between two mountainous regions the Dahra Range to the north and the Ouarsenis Mountains to the south.

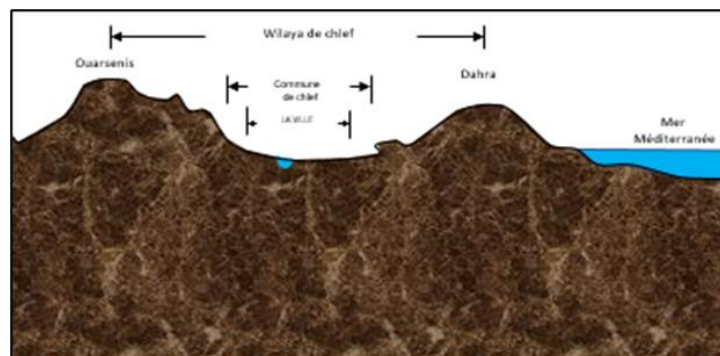
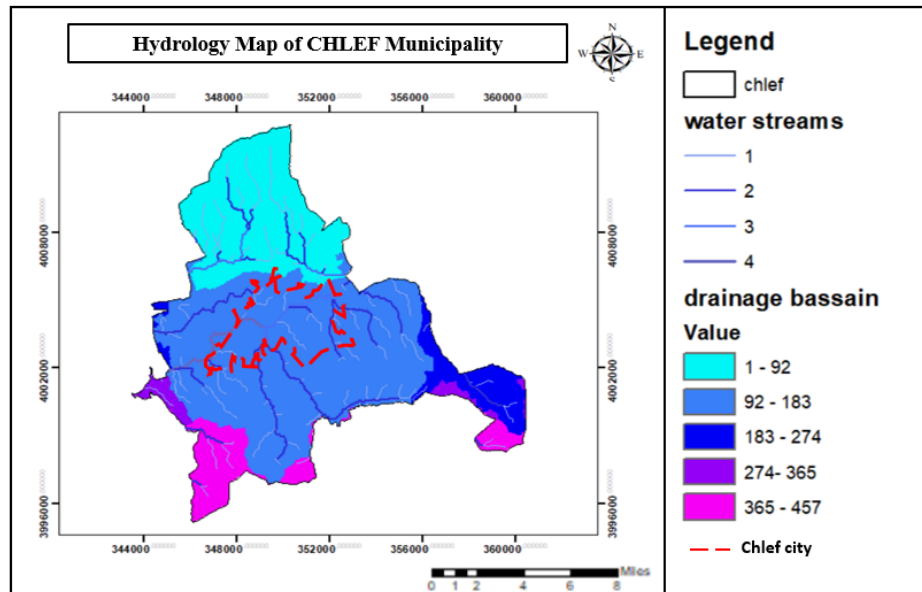


*Figure 41 Morphology of Chelf*

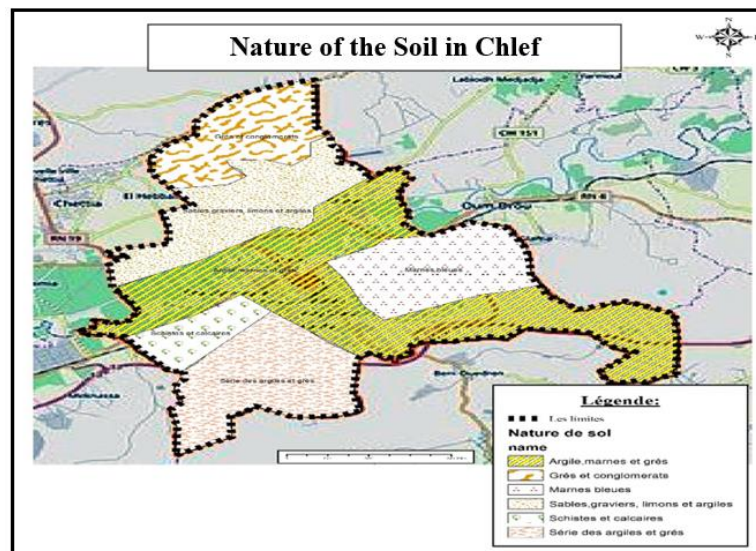
*Source:by author*



*Map 7 Hydrology Map of CHELF Municipality; Source:by author*

### 1.2.7 Nature of the Soil:

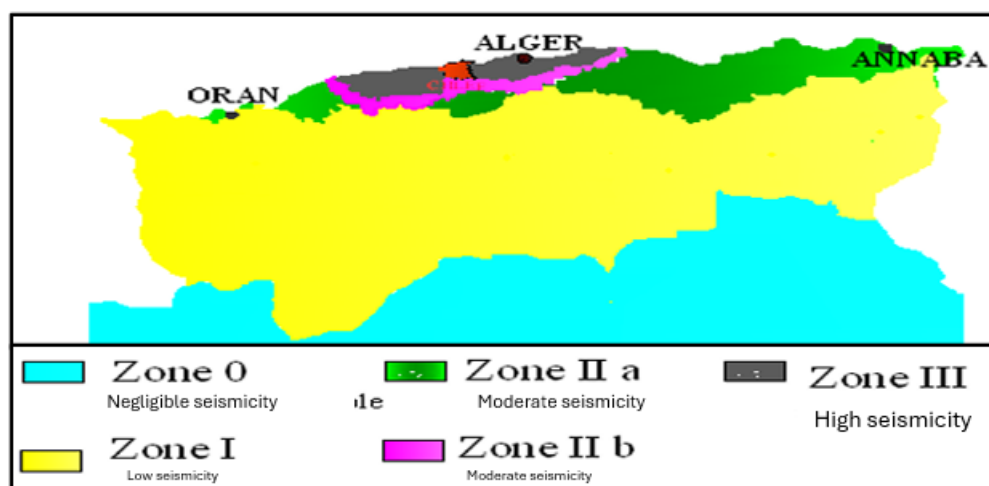
The soil in Chlef varies significantly across different areas, influenced by its diverse topography. It ranges from fertile alluvial soils in the plains and valleys, suitable for agriculture, to rocky and less arable soils in the mountainous regions. The coastal areas also feature sandy soils. This diversity affects land use and agricultural practices in the region.



*Map 8 Nature of the Soil in Chelf; Source:by author*

### 1.2.8 Major Risks:

According to the seismicity map of Algeria, the city of Chlef is classified in Zone III, indicating a high seismic risk, as per the Algerian earthquake-resistant regulations RPA99/2003.



*Map 9 Seismic Zoning Map of the National Territory*

### 1.2.9 Socio-Economic Analysis:

#### 1 Population:

- ✚ Area of the city: 3030 ha
- ✚ City population: 205,784 inhabitants
- ✚ Commune population: 236,912 inhabitants
- ✚ Population density (2008): 46 inhabitants/ha
- ✚ Population density (2020): 67 inhabitants/ha

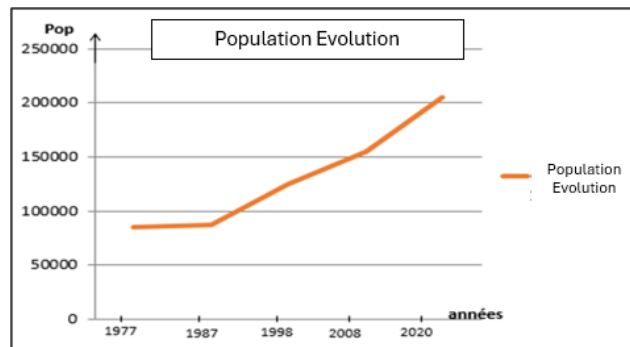
The population density of the city of Chlef has significantly increased due to rapid urbanization, driven by several factors:

1. The creation of emergency housing complexes after the 1980 earthquake, which accommodated a large population.
- Rural exodus to the city due to the availability of services.

#### 2 Population Growth:

*Table 2 Population Growth Data*

| Year       | 1977   | 1987   | 1998    | 2008    | 2020    |
|------------|--------|--------|---------|---------|---------|
| Population | 85,076 | 87,681 | 125,234 | 155,134 | 205,784 |



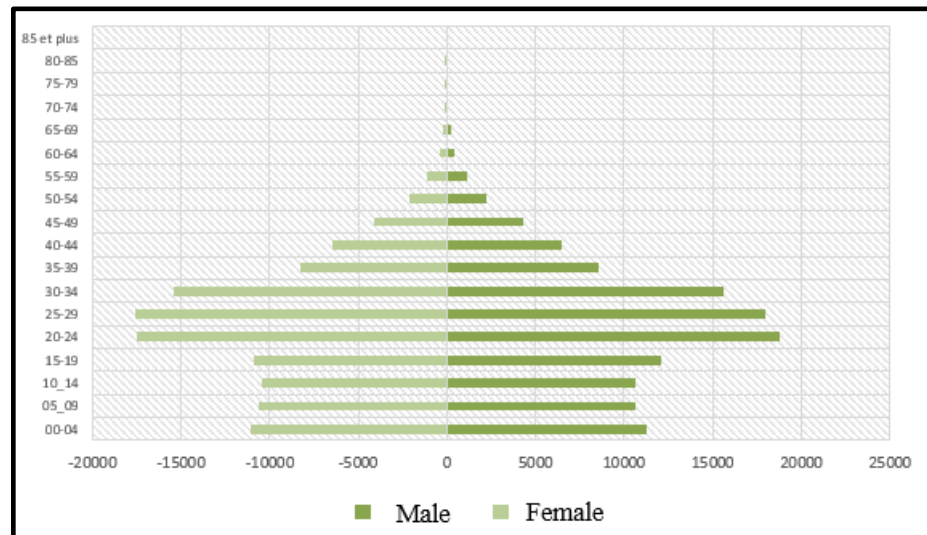
Graph 2 Population Growth of Chlef; Source:by author

This data illustrates the rapid urbanization of Chlef, with the population nearly doubling between 1998 and 2020. The significant population growth and increased density reflect the urban expansion and the city's role as a central hub for housing, services, and economic activities following the 1980 earthquake.

### 3 Population Growth and Urbanization in Chlef:

We observe a significant increase in the population of Chlef, with the 2020 statistics being notably higher compared to previous years. This suggests that the city has become increasingly attractive once again.

### 4 Population by Age Group:



Graph 3 Age Pyramid of Chlef; Source:by author

- The age pyramid features a broad base, with 56.5% of the population aged between 10 and 29 years. This demographic structure presents a future challenge, as significant

socio-economic changes will be necessary to accommodate the evolving needs of this large youth population.

○ **Employment and Activity:**

The following table provides a snapshot of the active population, unemployment rates, and employment rates in Chlef:

*Table 3 Active Population, Unemployment, and Employment Numbers*

| City         | Active Population | Activity Rate (%) | Unemployed Population | Unemployment Rate (%) | Employed Population | Employment Rate (%) |
|--------------|-------------------|-------------------|-----------------------|-----------------------|---------------------|---------------------|
| <b>Chlef</b> | 107,255           | 52.12%            | 12,960                | 12.08%                | 94,295              | 42.96%              |

**Source: PTAW, processed by the author**

- Chlef has a robust active population, and the unemployment rate is relatively low compared to the number of active individuals.

The data indicates that Chlef has experienced rapid urbanization, which is reflected in the significant population growth and changes in socio-economic structures. The city has become more attractive, possibly due to better infrastructure, economic opportunities, and housing developments. The young demographic will drive future socio-economic transformations, necessitating strategic planning to manage growth and employment.

**1.2.10 Natural; Economic and Touristic Assets:**

- ✓ the city of Chlef has diverse topographical features, including mountainous terrain, plains, intermontane valleys, and coastal regions influenced by the Tell Atlas Mountain range.
- ✓ Soil composition varies across regions, with fertile alluvial soils in the plains and valleys, rocky soils in mountainous areas, and sandy soils in coastal areas.
- ✓ the Chelif River traverses the wilaya from east to west, regulated by Oued Fodda and Sidi Yakoub dams. The region is served by two ports, enhancing its economic capabilities.
- ✓ Population density in Chlef has increased due to rapid urbanization, driven by post-1980 earthquake housing and rural-to-urban migration.
- ✓ Chlef has a robust active population with a low unemployment rate and significant employment levels, reflecting a dynamic economic environment.
- ✓ Hydraulic infrastructure improvements between 1999 and 2021 include increased potable water connections and enhanced sanitation services, supported by the Ténès seawater desalination plant.
- ✓ The climate in Chlef is classified as Mediterranean sub-humid, with sweltering summers and cold, rainy winters. The region experiences moderate and balanced precipitation, with varying temperature ranges throughout the year 4.
- ✓ Strategically positioned in northern Algeria, Chlef benefits from the RN04 and RN19 highways and a 120-kilometer Mediterranean coastline, enhancing its touristic appeal.

- ✓ Chlef is classified in Zone III for seismic risk according to the Algerian seismicity map, requiring robust infrastructure and planning.
- ✓ Rapid urbanization and the various urban projects in the city presents opportunities for tourism development, supported by expanding infrastructure and urban amenities.

### **1.3 El Hassania Neighbourhoods Scale (Intervention Area):**

The city of Chlef is undergoing significant transformation, as its population continues to grow. To address this rapid demographic increase, the state initiated a vast housing program in 2015 at El-Hassania quarter to accommodate nearly 20,000 residents, along with public facilities and a university hub. However, the project was halted due to financial issues.

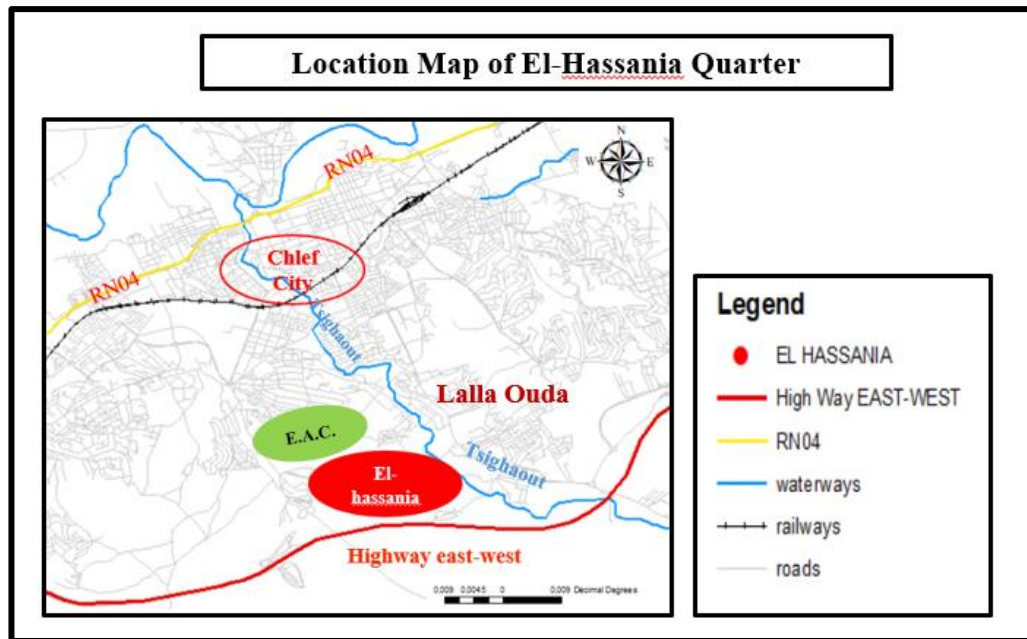
El-Hassania constitutes a post-seismic neighborhood predominantly characterized by prefabricated housing.

It stands as one of the two newly established urban areas emerging from the reconstruction efforts following the earthquake of October 10, 1980, in the city of Chlef. Its expansion manifests on either side of the railway line traversing the provincial capital.

Alongside residential zones, this locale accommodates decentralized administrative offices from the city center, alongside the establishment of new educational institutions such as the university and healthcare facilities including the forthcoming Cancer Treatment Center.

#### **1.3.1 Presentation of the El Hassania neighbourhoods:**

The site of El-Hassania is situated in the southwest region of the city of Chlef. To the north, delimited by tracks and agricultural lands of E.A.C, to the east by the Lalla Ouda district, To the east, bordered by the Tsighaouat River., and to the south by the east-west highway.



*Map 10 Location Map of El-Hassania Quarter; Source: by author*

### **1.3.2 Climatology:**

The El Hassania neighborhood is part of the city of Chlef, which is characterized by a Mediterranean climate. With hot, dry summers and mild, wet winters, Chlef experiences distinct seasonal variations in temperature and precipitation. These climatic conditions influence various aspects of life in the city, from agricultural practices to recreational activities

### **1.3.3 Urban Composition:**

The El-Hassania neighborhood is an urbanized area (with some zones still undergoing urbanization), primarily structured by a network of roads. It is also densely populated with residential buildings and equipped with some educative facilities. The residential area includes:

#### **1. Individual Housing:**

The area features existing individual constructions, which are arranged somewhat unorganized and in deteriorating condition.

Individual housing is increasingly irrationally occupying space. Access to these homes is provided by roadways along which they are aligned.

Individual houses usually feature 1 to 2 levels and are centrally located within their plots, surrounded by garden spaces. The plot sizes are typically medium.

**2. Collective Housing:**

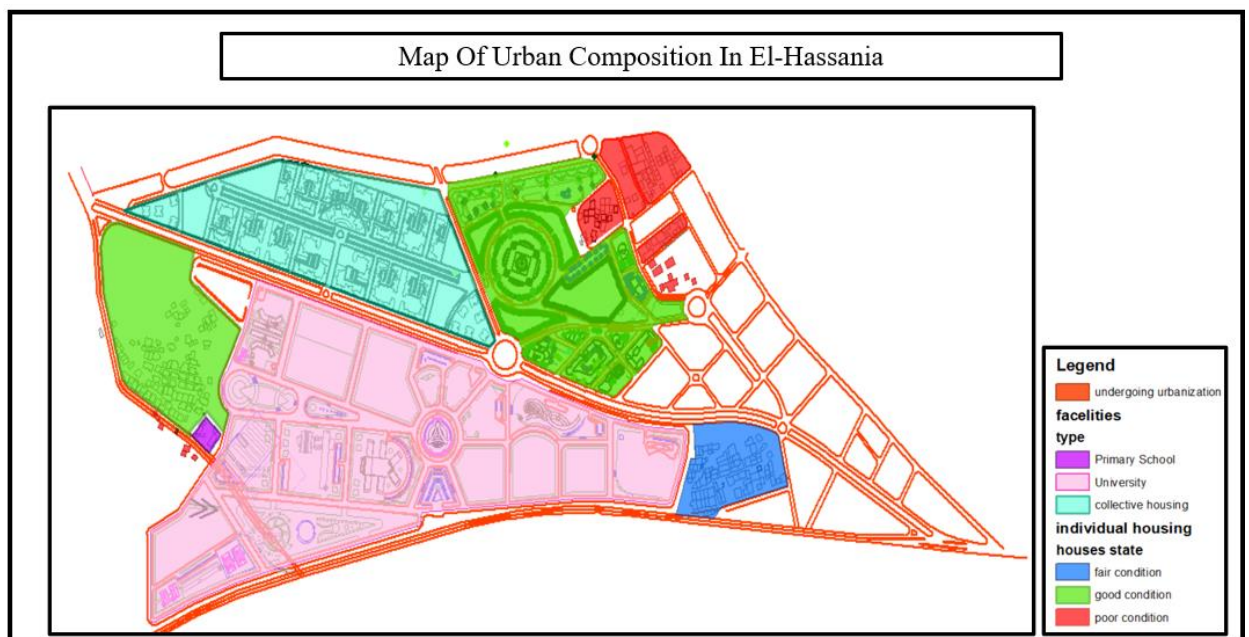
The neighborhood consists of 1500 AADEL housing units located in the central part of El-Hassania, characterized by a typology entirely different from the general style of the other constructions.

However, this contrast is softened by green spaces and facilities planned in its vicinity.

**3. Facilities:**

Facilities occupy a significant percentage of the area, primarily due to the large space occupied by the "Hassiba Ben Bouali" university hub, which has expanded the neighborhood's sphere of influence.

Additionally, the neighborhood includes only two other facilities: the primary school "Berkouk M'Hamed," which consists of 5 classrooms, and the university hub.



*Map 11 Map of Urban Composition in El-Hassania*

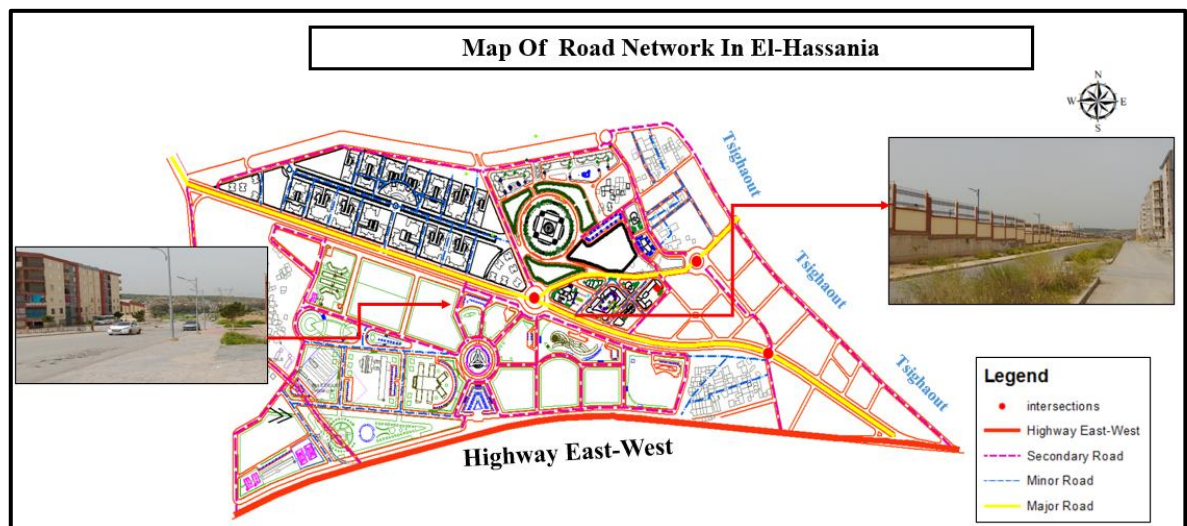
*Source:by author*

#### **1.3.4 Urban Infrastructure and Various Networks:**

- Road network

The El Hassania site is characterized by a dense traffic plan that supplies all parts of the city except for illegal housing areas, which necessitates a new parcel division for clear mobility and to avoid dead ends. We have noticed that the road layout does not meet the challenges of the topography. The site lacks bypass roads and connections to the East-West highway to improve city accessibility.

Additionally, we observed that the main road traversing our area, being the longest, plays a crucial role in the area's perception. El Hassania quarter lacks bicycle lanes and pedestrian pathways.



*Map 12 Map of Road Network in El-Hassania*

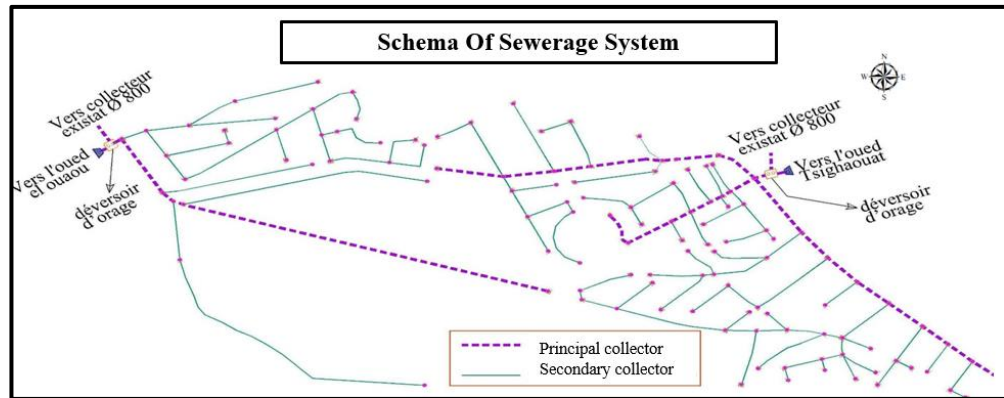
*Source:by author*

- Green and public spaces

Following our field visit, we observed that the El-Hassania site is significantly lacking in green spaces and public areas. It suffers from a shortage of gardens, squares, playgrounds, and proper public space planning. This situation restricts residents' opportunities to enjoy outdoor socialization and leisure areas, which are essential for a good quality of urban life.

- Sewerage system

The site features a recent unitary sewerage system, comprising reinforced concrete collectors with diameters of Ø300 mm, Ø400 mm, and Ø600 mm. These collectors transport wastewater to the Chlef sewage treatment plant through a main Ø800 mm collector

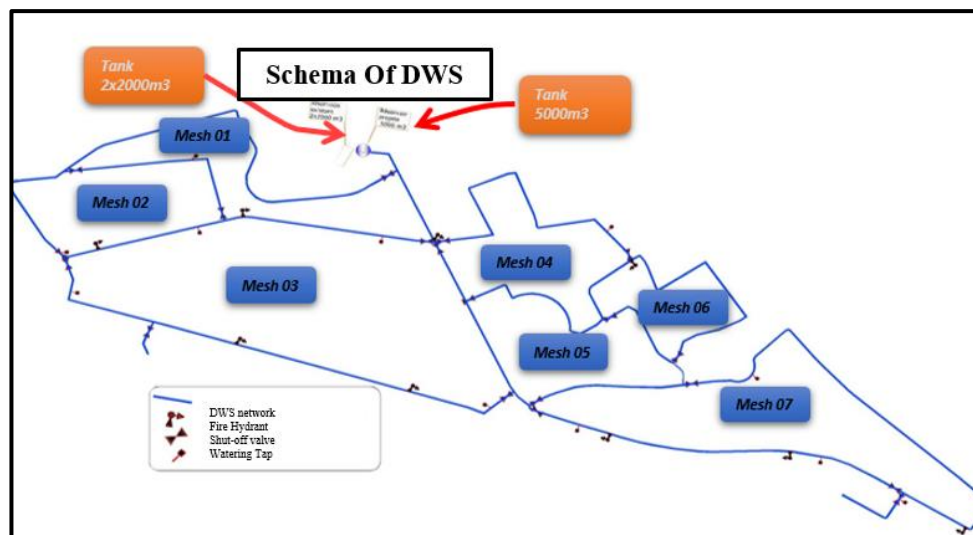


*Map 13 Schema of Sewerage System, Source:by author*

- Drinking water supply network

Our study area includes two types of water supply pipelines: distribution pipes and pumping pipes.

- ✓ Pumping pipes supply water to an existing reservoir on our site with a storage capacity of 2x2000 m<sup>3</sup>, with a diameter of Ø300 mm in cast iron.
- ✓ Distribution pipelines with diameters of Ø160 mm (HDPE) supply the site.



*Map 14 Schema of DWS; Source:by author*

### 1.3.5 Socio-economic analysis:

The population and housing analysis was derived from comprehensive survey data collected on-site by URBAB. The summarized results are presented in the following table:

*Table 4 Housing and Population Data In El-Hassania*

| Type of housing | Number of housing | Number of population |
|-----------------|-------------------|----------------------|
| Individual      | 320               | 2240                 |
| Collective      | 2000              | Uninhabited          |
| <b>Total</b>    | <b>2320</b>       | <b>2240</b>          |

**Source: URBAB Survey**

## 2. Distribution of Population by Age Group:

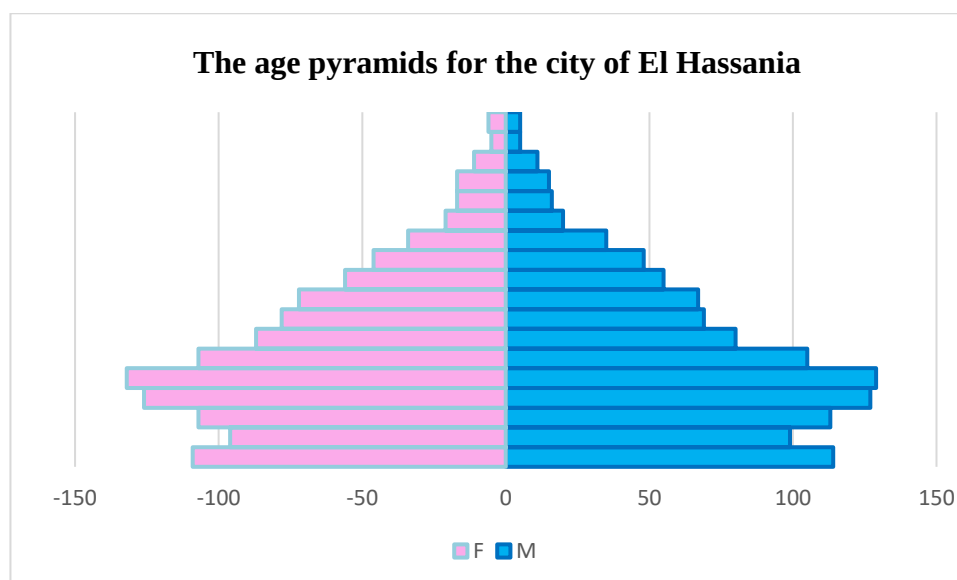
We conducted an age group distribution to better understand demographic variations and determine the population of school-going age. This age group distribution was obtained by referring to the data recorded by the 2008 General Population and Housing Census (RGPH) at the communal level.

*Table 5 Population Distribution by Age Groups*

| Age Group          | Male | Female | Total | Percentage |
|--------------------|------|--------|-------|------------|
| <b>0-4 years</b>   | 114  | 109    | 223   | 9.96%      |
| <b>5-9 years</b>   | 99   | 96     | 195   | 8.72%      |
| <b>10-14 years</b> | 113  | 107    | 220   | 9.82%      |
| <b>15-19 years</b> | 127  | 126    | 253   | 11.29%     |
| <b>20-24 years</b> | 129  | 132    | 260   | 11.63%     |
| <b>25-29 years</b> | 105  | 107    | 212   | 9.48%      |
| <b>30-34 years</b> | 80   | 87     | 166   | 7.43%      |
| <b>35-39 years</b> | 69   | 78     | 148   | 6.59%      |
| <b>40-44 years</b> | 67   | 72     | 139   | 6.19%      |
| <b>45-49 years</b> | 55   | 56     | 111   | 4.94%      |
| <b>50-54 years</b> | 48   | 46     | 94    | 4.20%      |
| <b>55-59 years</b> | 35   | 34     | 69    | 3.08%      |
| <b>60-64 years</b> | 20   | 21     | 41    | 1.81%      |

|                            |      |      |      |       |
|----------------------------|------|------|------|-------|
| <b>65-69 years</b>         | 16   | 17   | 33   | 1.49% |
| <b>70-74 years</b>         | 15   | 17   | 32   | 1.43% |
| <b>75-79 years</b>         | 11   | 11   | 22   | 0.99% |
| <b>80-84 years</b>         | 5    | 5    | 10   | 0.46% |
| <b>85 years &amp; over</b> | 3    | 4    | 7    | 0.32% |
| <b>ND</b>                  | 2    | 2    | 4    | 0.18% |
| <b>Total</b>               | 1113 | 1127 | 2240 | 100%  |

*Source: RGPH 2008*



*Graph 4 Graphic Represents Population Distribution by Age Groups;*

*Source:by author*

### **3. Schooling:**

In our study area, there is a primary school named BERKOUK MOHAMED, which comprises 5 classes with 99 students (2014-2015 school year). According to these data, the student-teacher ratio is 20 students per class. This ratio is lower than the target ratio set by the regional education authority, which is 30 students per class.

*Table 6 table represents the School Establishment in El-Hassania*

| <b>School Name</b>     | <b>NB of classes</b> | <b>Pedagogical Groups</b> | <b>Total Students</b> | <b>Occupied Students</b> | <b>TOC (Class Occupancy Rate)</b> |
|------------------------|----------------------|---------------------------|-----------------------|--------------------------|-----------------------------------|
| <b>BERKOUK M'HAMED</b> | 05                   | 05                        | 99                    | 33                       | 20                                |

*Source: Direction of Education and Teaching*

### **3.1 The potentials and weaknesses:**

1. **Strategic Location:** Situated in the southwest region of Chlef, El Hassania benefits from a well-connected location bordered by key landmarks, offering opportunities for further development and accessibility.
2. **Urban Composition:** The neighborhood features a mix of individual and collective housing units, along with a lack of facilities.
3. **Infrastructure Development:** El Hassania boasts a dense road network that serves the city, indicating potential for improved mobility and connectivity with proper planning and expansion.
4. **Educational and Healthcare Facilities:** With the presence of the university hub and forthcoming Cancer Treatment Center, El Hassania has the potential to become a hub for education and healthcare services, attracting residents and professionals alike.
5. **Growth Opportunities:** The ongoing housing program and expansion projects in El Hassania present opportunities for population growth, economic development, and urban revitalization, fostering a dynamic and vibrant community.
6. **Lack of Green Spaces:** El Hassania suffers from a shortage of green areas, public parks, and recreational spaces, limiting opportunities for outdoor socialization and leisure activities for residents.
7. **Inadequate Public Space Planning:** The neighborhood lacks proper planning for public areas, including bicycle lanes and pedestrian pathways, hindering the overall quality of urban life and safety for residents.
8. **Infrastructure Deficiencies:** Despite a dense road network, El Hassania requires new parcel divisions and bypass roads to address mobility challenges and enhance accessibility within the district.

9. **Limited Amenities:** Apart from educational facilities, El Hassania has a scarcity of public amenities such as gardens, squares, and playgrounds, impacting the overall livability and well-being of residents.
10. **Urban Decay:** Some individual housing units in El Hassania are disorganized and in deteriorating conditions, indicating a need for revitalization efforts and urban renewal to improve the neighborhood's aesthetic appeal and functionality.

#### **4. Analysis of Renewable Energy at El-Hassania Using SAM (System Advisor Model):**

SAM provides a comprehensive platform for modeling the performance and financial viability of renewable energy systems, particularly solar photovoltaic (PV) systems. It allows users to simulate the energy production of solar projects based on various inputs such as location, system design, and weather data. SAM incorporates detailed algorithms to estimate system performance under different conditions, helping developers, researchers, and policymakers make informed decisions about renewable energy investments.

##### **4.1 Applications of SAM:**

1. **Project Feasibility Studies:** Developers use SAM to assess the feasibility of solar PV projects by estimating energy production, financial metrics (like Levelized Cost of Energy - LCOE), and return on investment (ROI).
2. **System Design Optimization:** Engineers and designers utilize SAM to optimize the design and configuration of solar PV systems to maximize energy yield and efficiency.
3. **Policy Analysis:** Policymakers and researchers use SAM to evaluate the potential impacts of different policies, incentives, and regulations on the adoption and economics of solar energy.
4. **Education and Training:** SAM is also used as an educational tool in universities and training programs to teach students about renewable energy modeling and analysis.
5. **Research and Development:** Researchers use SAM to conduct studies on advanced solar technologies, energy storage integration, and grid integration challenges.

Overall, SAM plays a crucial role in advancing the adoption of solar energy by providing robust modeling capabilities that support decision-making across various sectors of the renewable energy industry and beyond.

##### **4.2 Analysing solar PV system in El-Hassania district using SAM:**

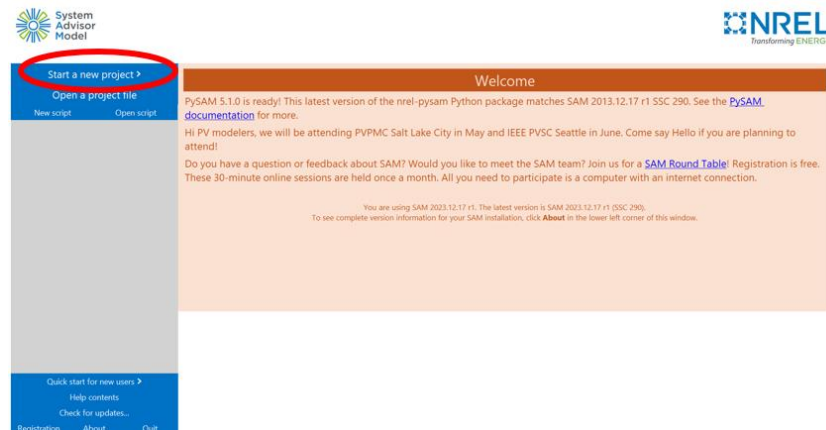
Let's begin with the analysis of solar energy using SAM. Here's a step-by-step to analyze a solar PV system for El-Hassania quarter.

##### **Step 1: Input Data into SAM**

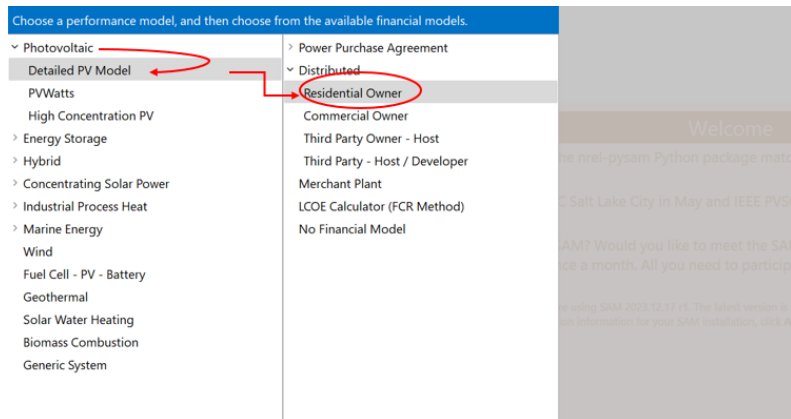
# CHAPTER IV: Into the Heart of Transformation: Analysing El-Hassania Quarter for Energy-Autonomous Solutions

2024

## 1. Open SAM and create a new project



## 2. Select the Photovoltaic the Detailed PV model then distribution and residential



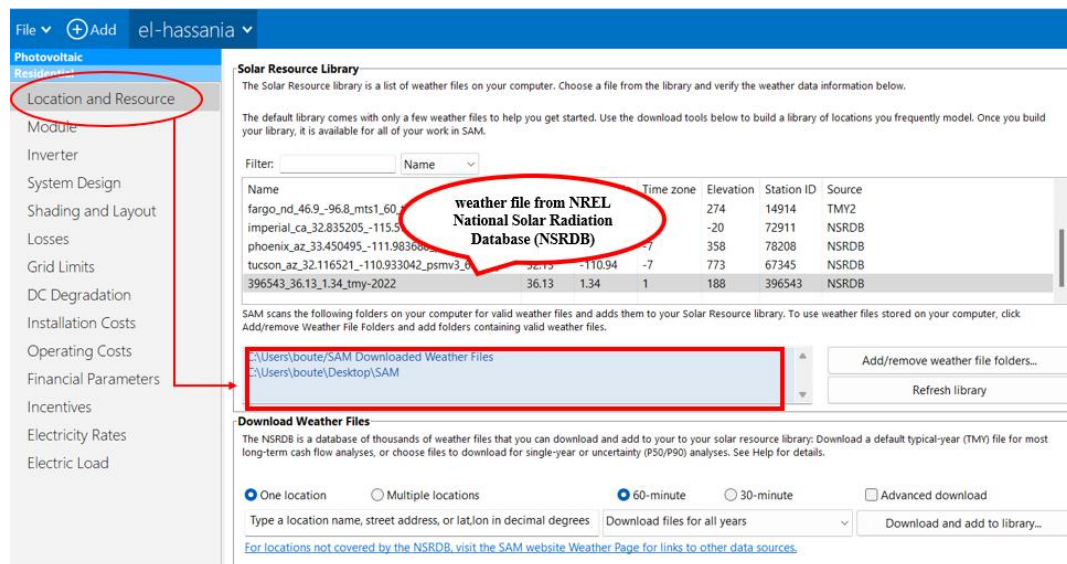
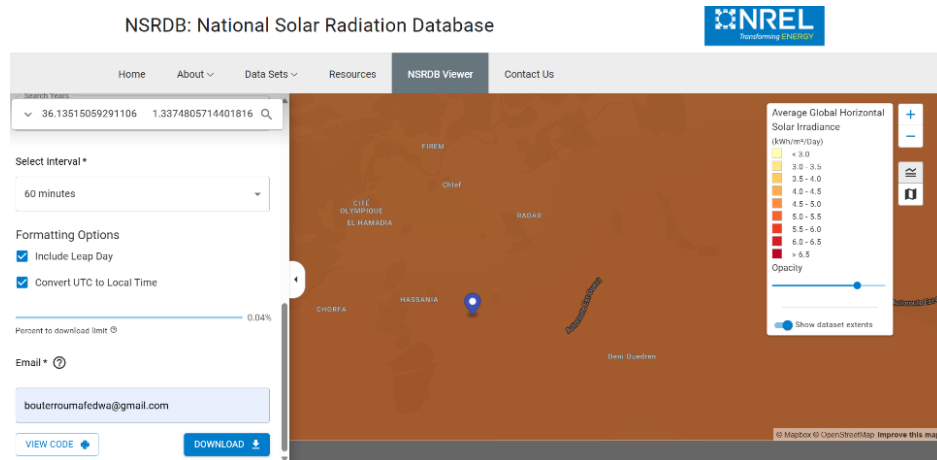
## Step 2: Set Up the Location and Solar Resource Data

### 1. Location:

- In the Location and Resource tab, we click on Download weather file from NREL National Solar Radiation Database (NSRDB).

## CHAPTER IV: Into the Heart of Transformation: Analysing El-Hassania Quarter for Energy-Autonomous Solutions

2024



### Step 3: Define System Parameters

#### 1. Module and Inverter Selection:

- In Module tab we select the type of PV module you will use (SunPower SPR-X21-345).

# CHAPTER IV: Into the Heart of Transformation: Analysing El-Hassania Quarter for Energy-Autonomous Solutions

2024

File Add el-hassania

Photovoltaic Residential

Location and Resource

Module

Inverter

System Design

Shading and Layout

Losses

Grid Limits

DC Degradation

Installation Costs

Operating Costs

Financial Parameters

Incentives

Electricity Rates

Electric Load

Simulate >

Parameters Stochastic

Uncertainty Macros

CEC Performance Model with Module Database

Filter: Name

| Name                    | Manufacturer | Technology | Bifacial | STC     | PTC   | A <sub>c</sub> | Length | Width | N <sub>s</sub> | I <sub>sc_ref</sub> | V <sub>oc_ref</sub> | I <sub>mp_ref</sub> | V <sub>mp_ref</sub> | alpha <sub>sc</sub> | beta <sub>oc</sub> | T <sub>c</sub> |
|-------------------------|--------------|------------|----------|---------|-------|----------------|--------|-------|----------------|---------------------|---------------------|---------------------|---------------------|---------------------|--------------------|----------------|
| SunPower SPR-X21-335    | SunPower     | Mono-c-Si  | 0        | 335.205 | 313.7 | 1.631          | 1.559  | 1.046 | 96             | 6.23                | 67.9                | 5.85                | 57.3                | 0.002492            | -0.16975           | 46             |
| SunPower SPR-X21-335... | SunPower     | Mono-c-Si  | 0        | 335.205 | 313.5 | 1.63           |        |       | 96             | 6.23                | 67.9                | 5.85                | 57.3                | 0.00216181          | -0.19175           | 45             |
| SunPower SPR-X21-335... | SunPower     | Mono-c-Si  | 0        | 335.205 | 313.7 | 1.631          | 1.559  | 1.046 | 96             | 6.23                | 67.9                | 5.85                | 57.3                | 0.002492            | -0.16975           | 46             |
| SunPower SPR-X21-335... | SunPower     | Mono-c-Si  | 0        | 335.205 | 313.7 | 1.631          | 1.559  | 1.046 | 96             | 6.23                | 67.9                | 5.85                | 57.3                | 0.002492            | -0.16975           | 46             |
| SunPower SPR-X21-335... | SunPower     | Mono-c-Si  | 0        | 335.205 | 313.5 | 1.63           |        |       | 96             | 6.23                | 67.9                | 5.85                | 57.3                | 0.0021805           | -0.191478          | 45             |
| SunPower SPR-X21-335... | SunPower     | Mono-c-Si  | 0        | 335.205 | 313.7 | 1.631          | 1.559  | 1.046 | 96             | 6.23                | 67.9                | 5.85                | 57.3                | 0.002492            | -0.16975           | 46             |
| SunPower SPR-X21-335... | SunPower     | Mono-c-Si  | 0        | 335.205 | 313.5 | 1.63           |        |       | 96             | 6.23                | 67.9                | 5.85                | 57.3                | 0.0021805           | -0.191478          | 45             |
| SunPower SPR-X21-335... | SunPower     | Mono-c-Si  | 0        | 335.205 | 313.5 | 1.63           |        |       | 96             | 6.23                | 67.9                | 5.85                | 57.3                | 0.0021805           | -0.191478          | 45             |

Module Characteristics at Reference Conditions

Reference conditions: Total Irradiance = 1000 W/m<sup>2</sup>, Cell temp = 25 °C

SunPower SPR-X21-335

Nominal efficiency 20.55 %

Maximum power (Pmp) 335.205 Wdc

Max power voltage (Vmp) 57.3 Vdc

Max power current (Imp) 5.8 Adc

Open circuit voltage (Voc) 67.9 Vdc

Short circuit current (Isc) 6.2 Adc

Temperature coefficients

-0.310 %/°C

-1.039 W/°C

-0.250 %/°C

-0.170 V/°C

0.040 %/°C

0.002 A/°C

Bifacial

Module is bifacial

Transmission fraction 0.013 0-1

Bifaciality 0.7 0-1

Ground clearance height 1 m

Temperature Correction

Nominal operating cell temperature (NOCT) method

Heat transfer method

See Help for information about cell temperature models.

NOCT Method Parameters

Mounting standoff Ground or rack mounted

T<sub>noct</sub> 46.4 °C

- In the Inverter tab, we select an appropriate inverter for our system(SMA Sunny Boy 5.0-US)

File Add el-hassania

Photovoltaic Residential

Location and Resource

Module

Inverter

System Design

Shading and Layout

Losses

Grid Limits

DC Degradation

Installation Costs

Operating Costs

Financial Parameters

Incentives

Electricity Rates

Electric Load

Inverter CEC Database

Filter: Name

| Name                                | Paco | Pdco    | Pso     | Pnt  | Vac | Vdcmx | Vdco | Mppt_high | Mppt_low | C0           | C1           | C2         | C3          |
|-------------------------------------|------|---------|---------|------|-----|-------|------|-----------|----------|--------------|--------------|------------|-------------|
| SMA America: SB5.0-1SP-US-40 [240V] | 5000 | 5155.06 | 32.2376 | 5... | 240 | 480   | 365  | 480       | 220      | -3.27495e-06 | -3.63102e-05 | 0.0017554  | 0.000115302 |
| SMA America: SB5.0-1SP-US-41 [208V] | 5050 | 5230.3  | 26.7937 | 5... | 208 | 480   | 365  | 480       | 220      | -3.64759e-06 | -3.01437e-05 | 0.00283192 | 0.000132854 |
| SMA America: SB5.0-1SP-US-41 [240V] | 5059 | 5217.07 | 31.9472 | 5... | 240 | 480   | 365  | 480       | 220      | -3.27291e-06 | -3.62646e-05 | 0.00179128 | 0.000192023 |
| SMA America: SB5.0-1TP-US-40 [208V] | 5000 | 5177.49 | 27.0084 | 5... | 208 | 480   | 365  | 480       | 220      | -3.63814e-06 | -3.17522e-05 | 0.0030215  | 0.00025222  |
| SMA America: SB5.0-1TP-US-40 [240V] | 5000 | 5155.06 | 32.2376 | 5... | 240 | 480   | 365  | 480       | 220      | -3.27495e-06 | -3.63102e-05 | 0.0017554  | 0.000115302 |

Efficiency Curve and Characteristics

SMA America: SB5.0-1TP-US-40 [240V]

Number of MPPT inputs 1

CEC weighted efficiency 96.901 %

European weighted efficiency 96.375 %

Datasheet Parameters

Maximum AC power 5000 Wac

Maximum DC power 5155.06 Wdc

Power use during operation 32.2376 Wdc

Power use at night 5.21 Wac

Nominal AC voltage 240 Vac

Maximum DC voltage 480 Vdc

Maximum DC current 14.1235 Adc

Minimum MPPT DC voltage 220 Vdc

Nominal DC voltage 365 Vdc

Maximum MPPT DC voltage 480 Vdc

Number of MPPT inputs is only available for systems with one inverter as specified on System Design page.

Sandia Coefficients

C0 -3.274950e-06 1/Wac

C1 -3.631020e-05 1/Vdc

C2 1.755400e-03 1/Vdc

C3 1.153020e-04 1/Vdc

CEC Information

CEC hybrid N

CEC type Utility Interactive

CEC date 2/15/2019

## 2. System Design:

- In the System Design tab, we enter the following parameters:
  - **Array Type:** Fixed Roof Mount.
  - **Array Tilt:** we set to the latitude of the location.
  - **Array Azimuth:** Set to 180°

The screenshot displays the SAM software interface for the 'el-hassania' project in the 'System Design' tab. The left sidebar lists various configuration categories, with 'System Design' currently selected. The main panel is divided into several sections:

- AC Sizing:** Includes fields for 'Number of inverters' (50) and 'DC to AC ratio' (1.68). A note states: 'Size the system using modules per string and strings in parallel inputs below.' There is an unchecked checkbox for 'Estimate Subarray 1 configuration'.
- Sizing Summary:** A table showing key system metrics:
 

|                            |              |                   |              |
|----------------------------|--------------|-------------------|--------------|
| Nameplate DC capacity      | 419.006 kWdc | Number of modules | 1,250        |
| Total AC capacity          | 250.000 kWac | Number of strings | 25           |
| Total inverter DC capacity | 257.753 kWdc | Total module area | 2,038.750 m² |
- DC Sizing and Configuration:** A note explains how to model a system with one array or up to four subarrays. Below is a table for subarray configuration:
 

|                                        | Subarray 1       | Subarray 2                      | Subarray 3                      | Subarray 4                      |
|----------------------------------------|------------------|---------------------------------|---------------------------------|---------------------------------|
| <b>Electrical Configuration</b>        | (always enabled) | <input type="checkbox"/> Enable | <input type="checkbox"/> Enable | <input type="checkbox"/> Enable |
| Modules per string in subarray         | 50               |                                 |                                 |                                 |
| Strings in parallel in subarray        | 25               |                                 |                                 |                                 |
| Number of modules in subarray          | 1,250            |                                 |                                 |                                 |
| String Voc at reference conditions (V) | 3,395.0          |                                 |                                 |                                 |
| String Vmp at reference conditions (V) | 2,865.0          |                                 |                                 |                                 |
- Multiple MPPT Inputs:** A field for 'Set MPPT inputs' is set to 1. A note says: 'Set MPPT inputs when Number of MPPT Inputs on the Inverter page is greater than 1.'
- Tracking & Orientation:** Includes a diagram of a solar array and radio buttons for 'Fixed', '1 Axis', '2 Axis', 'Azimuth Axis' (selected), and 'Seasonal Tilt'. Below these, there are checkboxes for 'Tilt=latitude' (unchecked) and 'Tilt=deg' (checked). The 'Tilt (deg)' field is highlighted with a red circle and labeled 'latitude of El-Hassania'. The 'Azimuth (deg)' field is set to 180. A 'Ground coverage ratio (GCR)' field is set to 0.3.

## Step 4: Save and Simulate

1. **Save Settings:** Save your settings after inputting all the necessary data.
2. **Run Simulation:** we click on Simulate to run the analysis. SAM generates results based on our location data potential.

## 2024



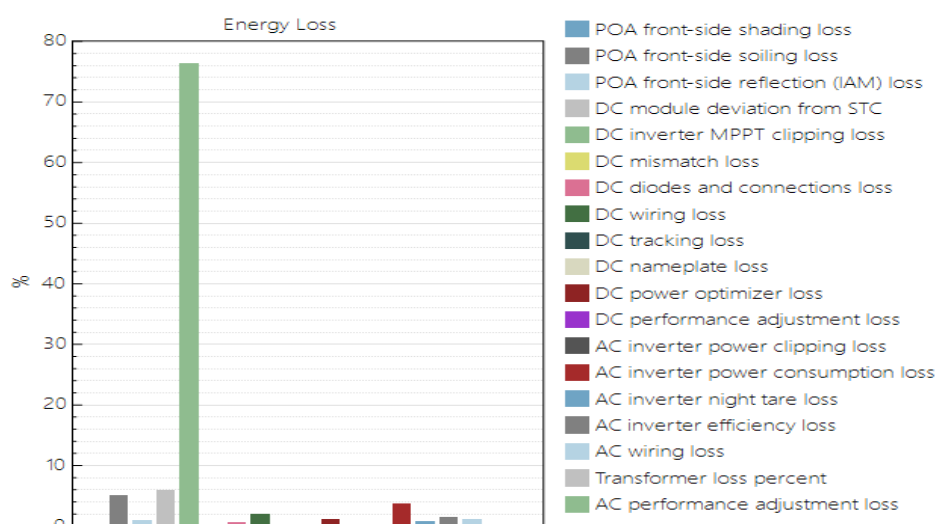
#### 4.3.2 Performance Ratio (PR)

The average performance ratio of 0.82 indicates that the system can operate efficiently throughout the year. Minor fluctuations are observed, primarily due to seasonal changes and occasional shading. These results highlight the importance of maintaining optimal conditions for the PV system to maximize performance.

#### 4.3.3 System Losses

The system losses are categorized as follows:

- **Shading Losses:** 2%
- **Soiling Losses:** 3%
- **Inverter Losses:** 5%
- **Other Losses:** 2%



*Graph 5 Energy loss*

#### 4.3.4 Financial Metrics

The financial analysis reveals a payback period of 6 years, an NPV of \$120,000, and an IRR of 10%. These metrics indicate a financially viable project with a reasonable return on investment. The shorter payback period and positive NPV make solar PV installation an attractive option for achieving energy autonomy in El-Hassania.

### **5. Urban Planning Perspectives in Chlef: A Conversation with the Experts**

To gain insights into the urban planning challenges faced by Chlef, I conducted an interview with an employee at the Municipal Technical Service and a representative from the Urban Planning Agency (URBAB).

Through this dialogue, I sought to understand their perspectives on the city's current state and future aspirations towards becoming a smart city. Both respondents highlighted pressing issues such as inefficient infrastructure, limited green spaces, traffic congestion, and inadequate waste management. Despite these challenges, there is a noticeable gap in the government's overarching vision for Chlef as a smart city.

While the interviews emphasized the need for immediate improvements in sustainable infrastructure, smart transportation systems, and the integration of advanced technologies like IoT sensors and smart grids, these efforts appear more reactive than part of a comprehensive, forward-looking strategy. Key barriers, including the high costs of infrastructure upgrades, the need for public awareness campaigns, and the challenge of scaling city-wide initiatives, were acknowledged.

Moving forward, fostering stronger collaboration among government agencies, private sectors, and community stakeholders will be crucial. This collaborative approach can help establish a unified vision and robust framework necessary to propel Chlef towards a sustainable and prosperous future as a smart city, effectively addressing current urban challenges and accommodating future growth.

### **6. Case Study Analysis and Survey Results Interpretation:**

The questionnaire we designed comprises 22 questions aimed at the residents of the El-Hassania quarter. The survey assesses the feasibility of transitioning their quarter into an energy-autonomous smart district.

To analyze our data, we utilized SPSS (Statistical Package for the Social Sciences), a robust software tool well-suited for data analysis, including univariate, bivariate, and multivariate analyses. SPSS offers various statistical tests and methods pertinent to descriptive statistics.

The data collection process involved several steps: data collection, sorting, and encoding. SPSS facilitates this process by providing various methods and tests, though our primary focus was on frequencies and percentages. The workflow was divided into three main stages: variable entry, data insertion, and analysis, with the variable entry phase being the most critical. Below are some key sections of the work conducted :

#### **6. The first step: Entering the variables**

## CHAPTER IV: Into the Heart of Transformation: Analysing El-Hassania Quarter for Energy-Autonomous Solutions

2024

- Definition of a variable and its properties
- Under the NAME column: enter the encoded question number.

|    | Nom                | Type      | Largeur | Décimales | Libellé                                                                                 | Valeurs          | Manquant | Colonnes | Align  | Mesure  | Rôle   |
|----|--------------------|-----------|---------|-----------|-----------------------------------------------------------------------------------------|------------------|----------|----------|--------|---------|--------|
| 4  | job                | Numérique | 8       | 2         | What do you do in your life?                                                            | (1,00, Stude...  | Aucun    | 8        | Droite | Inconnu | Entrée |
| 5  | avalla.pc          | Numérique | 8       | 2         | Do you have a computer at home (desktop or laptop)?                                     | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 6  | internet.home      | Numérique | 8       | 2         | Do you have an internet connection at home?                                             | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 7  | device             | Numérique | 8       | 2         | Which of these devices do you use to access the internet?                               | (1,00, Deskt...  | Aucun    | 8        | Droite | Inconnu | Entrée |
| 8  | frequency          | Numérique | 8       | 2         | How often do you use the internet?                                                      | (1,00, Rarel...  | Aucun    | 8        | Droite | Inconnu | Entrée |
| 9  | persons            | Numérique | 8       | 2         | How many people live in your household?                                                 | (1,00, 2-4 p...  | Aucun    | 8        | Droite | Inconnu | Entrée |
| 10 | connected.prns     | Numérique | 8       | 2         | Are all individuals in your household connected to the internet?                        | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 11 | internet.essent... | Numérique | 8       | 2         | Do you consider the internet an essential tool in your daily life?                      | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 12 | payment            | Numérique | 8       | 2         | Do you use online payment/ticketing applications?                                       | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 13 | online.services    | Numérique | 8       | 2         | How often do you use online services?                                                   | (1,00, Never...  | Aucun    | 8        | Droite | Inconnu | Entrée |
| 14 | digit.administ     | Numérique | 8       | 2         | What do you think about digitizing services?                                            | (1,00, Yes, L... | Aucun    | 8        | Droite | Inconnu | Entrée |
| 15 | smart.devices      | Numérique | 8       | 2         | Do you know what smart devices are?                                                     | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 16 | devices.own        | Numérique | 8       | 2         | Do you own a smart device (watch, drone, car, smartphone)?                              | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 17 | sm.dev.home        | Numérique | 8       | 2         | Do you agree to install smart devices in your home?                                     | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 18 | smart.city         | Numérique | 8       | 2         | Do you know what a smart city is?                                                       | (1,00, Yes, L... | Aucun    | 8        | Droite | Inconnu | Entrée |
| 19 | renew.energy       | Numérique | 8       | 2         | Do you know what renewable energy is?                                                   | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 20 | RE.known           | Numérique | 8       | 2         | Do you know about any of this forms of renewable energy used in your local environment? | (1,00, Solar...  | Aucun    | 8        | Droite | Inconnu | Entrée |
| 21 | RE.home            | Numérique | 8       | 2         | Do you agree to have your home equipped with renewable energy systems?                  | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 22 | enrgy.auton.quar   | Numérique | 8       | 2         | Do you have prior knowledge about energy-autonomous quarters?                           | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |
| 23 | S.E.A.Q.agree      | Numérique | 8       | 2         | Are you agree to have your district become a smart energy-autonomous quarter?           | (1,00, Yes)...   | Aucun    | 8        | Droite | Inconnu | Entrée |

Under the VALUES column: we enter the options for the question (to facilitate data entry later). For example, internet using frequency: 1/Rarely, 2/Once a week, 3/Less than an hour a day, 4/More than an hour a day.

|    | Nom                | Type      | Largeur | Décimales | Libellé                                             | Valeurs         | Manquant | Colonnes | Align  | Mesure    | Rôle   |
|----|--------------------|-----------|---------|-----------|-----------------------------------------------------|-----------------|----------|----------|--------|-----------|--------|
| 1  | VAR00006           | Numérique | 8       | 2         |                                                     | Aucun           | Aucun    | 8        | Droite | Nominales | Entrée |
| 2  | Gender             | Numérique | 8       | 2         | what's your Gender?                                 | (1,00, male)... | Aucun    | 8        | Droite | Nominales | Entrée |
| 3  | age                | Numérique | 8       | 2         | age category?                                       | (1,00, 15-29... | Aucun    | 8        | Droite | Ordinales | Entrée |
| 4  | job                | Numérique | 8       | 2         | What do you do in your life?                        | (1,00, Stude... | Aucun    | 8        | Droite | Nominales | Entrée |
| 5  | avalla.pc          | Numérique | 8       | 2         | Do you have a computer at home (desktop or laptop)? | (1,00, Yes)...  | Aucun    | 8        | Droite | Nominales | Entrée |
| 6  | internet.home      | Numérique | 8       | 2         | Do you have an internet connection at home?         | (1,00, Yes)...  | Aucun    | 8        | Droite | Nominales | Entrée |
| 7  | device             | Numérique | 8       | 2         | Which of these devices do you use                   |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 8  | frequency          | Numérique | 8       | 2         | How often do you use the internet?                  |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 9  | persons            | Numérique | 8       | 2         | How many people live in your hous                   |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 10 | connected.prns     | Numérique | 8       | 2         | Are all individuals in your househo                 |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 11 | internet.essent... | Numérique | 8       | 2         | Do you consider the internet an ess                 |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 12 | payment            | Numérique | 8       | 2         | Do you use online payment/ticketin                  |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 13 | online.services    | Numérique | 8       | 2         | How often do you use online servic                  |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 14 | digit.administ     | Numérique | 8       | 2         | What do you think about digitizing s                |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 15 | smart.devices      | Numérique | 8       | 2         | Do you know what smart devices a                    |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 16 | devices.own        | Numérique | 8       | 2         | Do you own a smart device (watch,                   |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 17 | sm.dev.home        | Numérique | 8       | 2         | Do you agree to install smart devic                 |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 18 | smart.city         | Numérique | 8       | 2         | Do you know what a smart city is?                   |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 19 | renew.energy       | Numérique | 8       | 2         | Do you know what renewable ener                     |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 20 | RE.known           | Numérique | 8       | 2         | Do you know about any of this form                  |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 21 | RE.home            | Numérique | 8       | 2         | Do you agree to have your home ec                   |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 22 | enrgy.auton.quar   | Numérique | 8       | 2         | Do you have prior knowledge about                   |                 | Aucun    | 8        | Droite | Nominales | Entrée |
| 23 | S.E.A.Q.agree      | Numérique | 8       | 2         | Are you agree to have your district                 |                 | Aucun    | 8        | Droite | Nominales | Entrée |

Libellés de valeurs

| Valeur | Libellé                 |
|--------|-------------------------|
| 1,00   | Rarely                  |
| 2,00   | Once a week             |
| 3,00   | Less than an hour a day |
| 4,00   | More than an hour a day |

OK Réinitialiser Annuler Aide

In the Value Labels section, under Value, enter the number corresponding to the option (ex,1); under Label, enter the option's name (ex, Rarely for 1). Continue adding each option until all values are entered, then click OK.

- The second step: Data Entry:

## CHAPTER IV: Into the Heart of Transformation: Analysing El-Hassania Quarter for Energy-Autonomous Solutions

2024

- Enter the data for each individual according to their answers.

| VAR00006 | Gen der | age             | job        | availa pc | internet home | device                                | frequency               | persons    | online servi ces | digit.administ               |
|----------|---------|-----------------|------------|-----------|---------------|---------------------------------------|-------------------------|------------|------------------|------------------------------|
| 194      | male    | 30-49 yo        | employee   | yes       | yes           | Laptop                                | Less than an hour a day | 6-8 people | yes              | Yes, I think it's beneficial |
| 195      | male    | 30-49 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | More than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 196      | female  | 30-49 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | More than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 197      | female  | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | More than an hour a day | 4-6 people | yes              | Yes, I think it's beneficial |
| 198      | male    | 15-29 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | More than an hour a day | 4-6 people | yes              | Yes, I think it's beneficial |
| 199      | female  | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 190      | male    | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | More than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 191      | female  | 15-29 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 2-4 people | yes              | Yes, I think it's beneficial |
| 192      | male    | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 2-4 people | yes              | Yes, I think it's beneficial |
| 193      | female  | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 2-4 people | yes              | Yes, I think it's beneficial |
| 194      | male    | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 2-4 people | yes              | Yes, I think it's beneficial |
| 195      | female  | 30-49 yo        | unemployed | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 4-6 people | yes              | Yes, I think it's beneficial |
| 196      | female  | 30-49 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 2-4 people | yes              | Yes, I think it's beneficial |
| 197      | female  | 15-29 yo        | unemployed | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 2-4 people | yes              | Yes, I think it's beneficial |
| 198      | male    | 30-49 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 4-6 people | yes              | Yes, I think it's beneficial |
| 199      | female  | 30-49 yo        | unemployed | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 4-6 people | yes              | Yes, I think it's beneficial |
| 200      | male    | 30-49 yo        | unemployed | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 2-4 people | yes              | Yes, I think it's beneficial |
| 201      | male    | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 202      | female  | more than 70 yo | retired    | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 4-6 people | yes              | Yes, I think it's beneficial |
| 203      | male    | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | More than an hour a day | 4-6 people | yes              | Yes, I think it's beneficial |
| 204      | female  | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 205      | male    | 30-49 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | Rarely                  | 2-4 people | yes              | Yes, I think it's beneficial |
| 206      | male    | 15-29 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 207      | male    | 15-29 yo        | unemployed | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 208      | female  | 15-29 yo        | student    | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 2-4 people | yes              | Yes, I think it's beneficial |
| 209      | male    | 30-49 yo        | employee   | yes       | yes           | Mobile phone with 4G or 5G connection | Less than an hour a day | 4-6 people | yes              | Yes, I think it's beneficial |

The third step:

- For analysis, we conducted the analysis using the following syntax: Analyze > Descriptive Statistics > Frequencies.

Variable(s):

☒ Afficher les tables de fréquences

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Based on this questionnaire, we derived the following results:

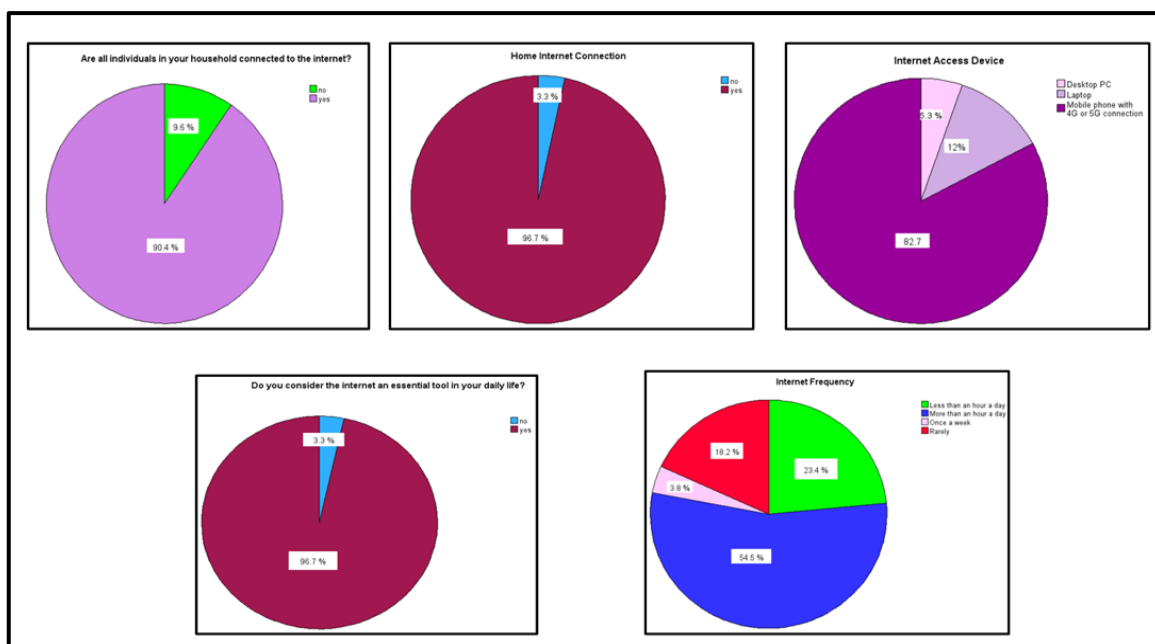


Figure 42 The connection rate of the district

Interestingly, 96.7% of respondents have access to the internet, and 90.4% of them are actively connected. More than 80% of them use their 4G-enabled mobile phones to access the internet multiple times a day.

The majority of the respondents consider the internet as an essential tool for daily life.

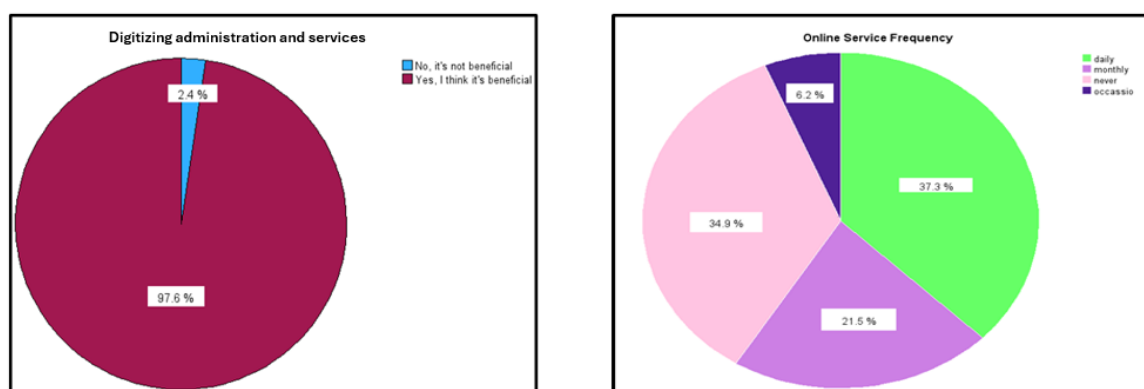


Figure 43 Smart Service and Administration

37.3% of the respondents use online services daily, indicating a significant portion of daily users. Additionally, 21.5% of the respondents use online services monthly, suggesting consistent but less frequent usage. Surprisingly, a sizeable proportion, 34.9% of the respondents, reported never using online services. This finding highlights a significant portion

of the population that does not engage with online services at all. Furthermore, 6.2% of the respondents reported using online services occasionally

Overwhelmingly, 97.6% of respondents agreed that digitizing administrations and services is beneficial, while the remaining percentage of respondents disagreed. This high percentage of agreement suggests strong support for the idea of digitizing administrations and services among the surveyed individuals. It also indicates a consensus among most respondents that digitization can bring positive outcomes or benefits.

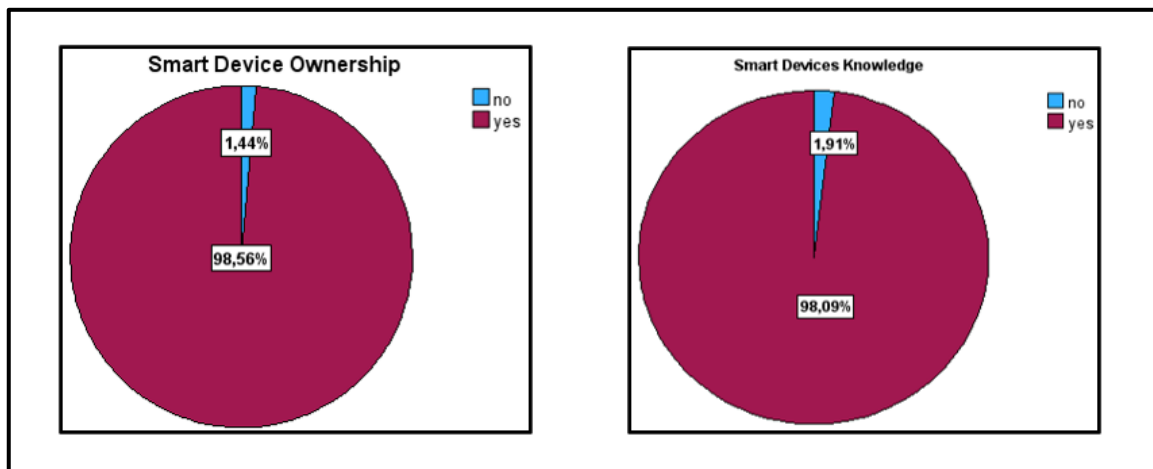


*Figure 44 Smart Devices*

98.09% of respondents know smart devices, This extremely high percentage of respondents knowing smart devices such as smartphones, smart home devices, or wearable technology suggests a high level of awareness and understanding of smart devices among the population. while only 1.91% of them don't.

Based on the respondents' answers, 98.56% own smart devices, while the remaining percentage do not. This extremely high percentage of smart device ownership suggests that most surveyed individuals have adopted smart devices, which are often characterized by their ability to connect to the internet and perform various tasks autonomously.

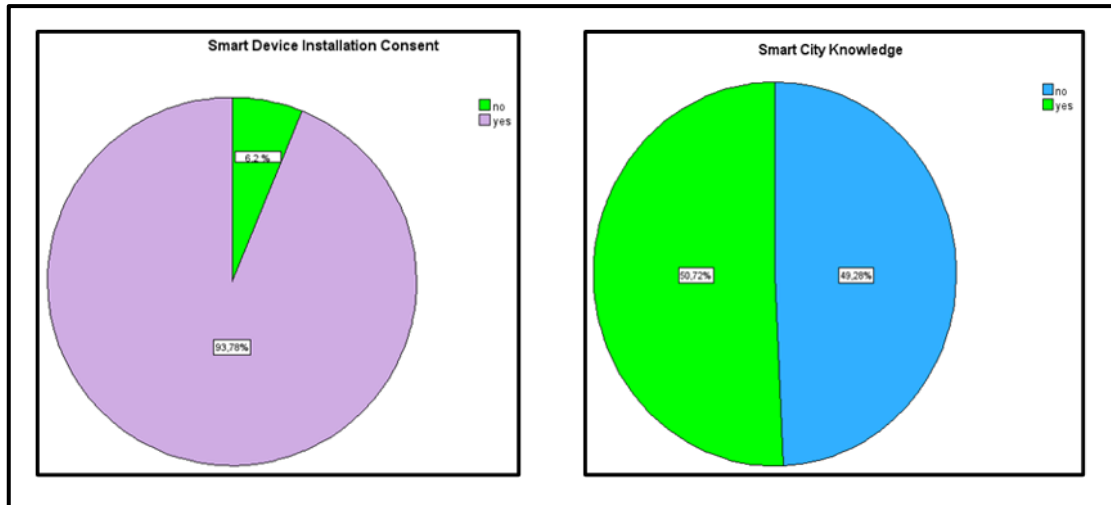


*Figure 45 Smart City Knowledge*

According to the results, 50.72% of respondents said "yes" to knowing smart cities, indicating a moderate level of understanding. However, 49.28% said "no", suggesting a significant lack of familiarity with the concept. On the other hand, a strong majority of respondents (93.78%) are willing to consent to the installation of smart devices, indicating a high level of adoption and acceptance. Only 6.2% of respondents are hesitant or unwilling to have smart devices installed, indicating a relatively low resistance to this technology.

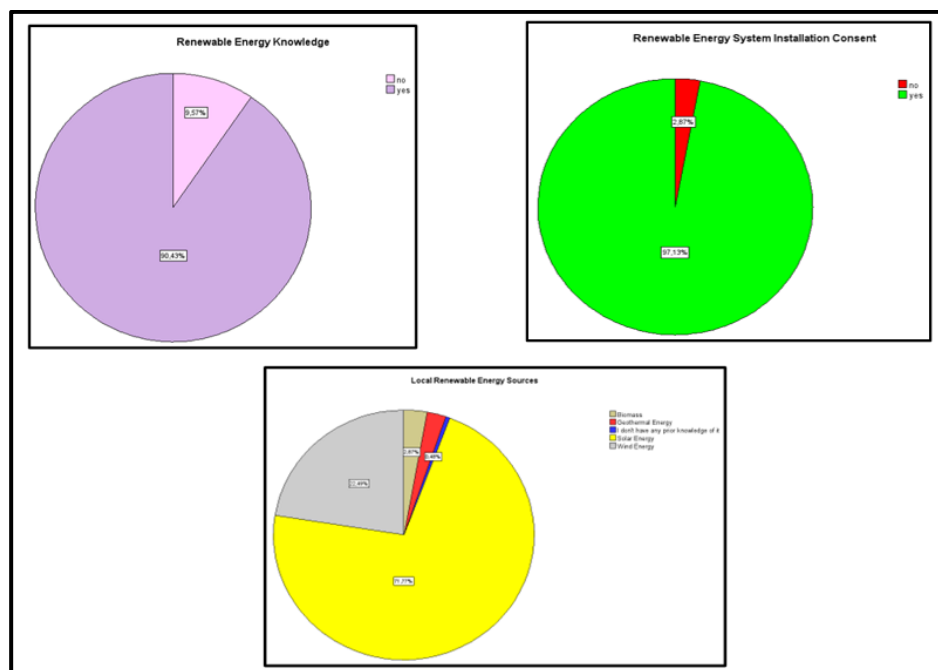


*Figure 46 Renewable Energy Knowledge*

The majority of respondents 90.4% know renewable energy, while 9.6% lack knowledge about this topic. This shows a strong awareness and comprehension of renewable energy.

In terms of installing renewable energy systems, an overwhelming 97.1% of respondents consent to the installation of such systems, showing a strong willingness to adopt renewable energy solutions.

The breakdown of local renewable energy usage shows that solar energy is the most popular option, with 71.8% of respondents choosing it. Wind energy is a distant second, with 22.5% of respondents opting for it. Biomass, geothermal, and wind energy are less popular, with 2.9%, 2.4%, and 0.5% of respondents choosing them, respectively.

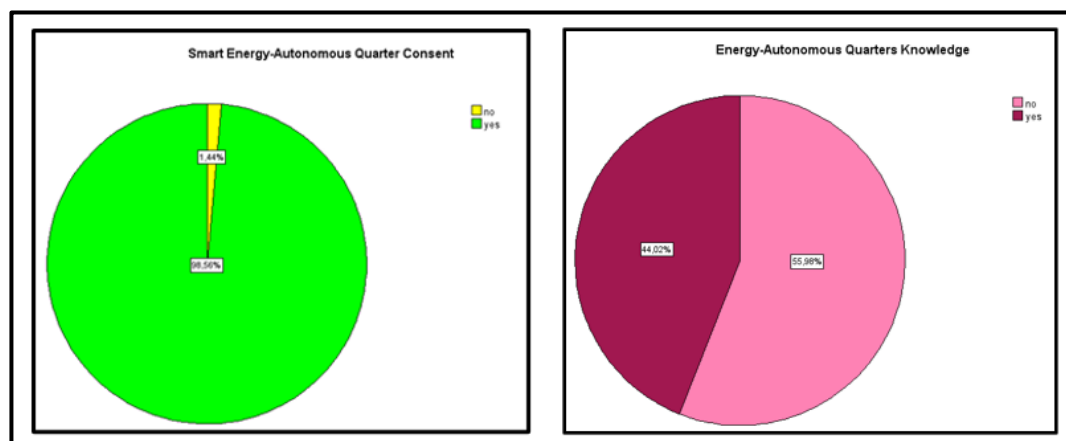


*Figure 47 Energy Autonomous Quarter Transformation*

According to the data, 56% of respondents said "yes" to knowing energy-autonomous districts, while 44% said "no". This suggests that there may be a lack of awareness or understanding about energy-autonomous districts among the population. On the other hand, there is overwhelming support when it comes to having their district become a smart energy-autonomous quarter. 98.6% of respondents said "yes" to agree to have their district become a smart energy-autonomous quarter, while only 1.4% said "no".

Despite the significant gap in knowledge about energy-autonomous districts, there is a clear consensus among respondents when it comes to supporting the idea of smart energy-autonomous districts. This could be due to various factors such as perceived benefits, environmental concerns, or economic opportunities.

After conducting a thorough analysis, we have found that the connectivity rate is sufficient, and citizens have overwhelmingly supported the concept of creating a smart energy-autonomous quarter in El Hassania. Building on this momentum, we will develop a

comprehensive project to transform the quarter into a smart energy-autonomous quarter, leveraging the latest technologies and innovations to achieve this goal.

**7. Evaluation of El-Hassania Neighborhood According to GIFFINGER Criteria:**

Through an on-site study and interviews conducted with residents and officials of the neighborhood, we aim to conduct an assessment of our study area based on the criteria and indicators developed by Rudolf GIFFINGER. These six GIFFINGER criteria for a smart city, presented hierarchically in the following table, represent a logical progression of processes or stages through which a city evolves into a smart city.

*Table 7 GIFFINGER Criteria*

|                  | Factors of a Smart City                                                                                                                                                                                                                                                                 | Evaluation of the case study                                                                                                                                                                                                                                                                                                                                                      |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Smart Governance | <ul style="list-style-type: none"> <li>- E-governance</li> <li>- Connectivity</li> <li>- Transparency</li> <li>- Open Data</li> <li>- Use of ICT</li> <li>- Integration of technologies</li> <li>- Citizen participation in decision-making</li> </ul>                                  | <ul style="list-style-type: none"> <li>- Non-connected administration</li> <li>- Closed and non-transparent governance</li> <li>- Lack of quality in services provided to citizens</li> <li>- Lack of genuine citizen participation, where citizens are merely sources of data and decisions are made by the community</li> <li>- Absence of data sharing and openness</li> </ul> |
| Smart Citizen    | <ul style="list-style-type: none"> <li>- Eco-citizen</li> <li>- Citizen involvement</li> <li>- Open society</li> <li>- Creativity</li> <li>- Education level</li> <li>- Learning</li> <li>- Use of smart devices</li> </ul>                                                             | <ul style="list-style-type: none"> <li>- Lack of citizen participation in city creation.</li> <li>- Absence of creativity, flexibility, and community participation among citizens.</li> </ul>                                                                                                                                                                                    |
| Smart Economy    | <ul style="list-style-type: none"> <li>- Productivity</li> <li>- Entrepreneurship and innovation</li> <li>- Interconnection of territories</li> <li>- Job creation</li> <li>- Market flexibility</li> <li>- Economic development</li> <li>- Attraction of foreign investment</li> </ul> | <ul style="list-style-type: none"> <li>- Lack of productivity</li> <li>- Difficulty in attracting new businesses to the city center</li> <li>- Insufficient financial resources for local authorities to meet their obligations</li> </ul>                                                                                                                                        |
| Smart Mobility   | <ul style="list-style-type: none"> <li>- Multimodal access</li> <li>- Development of sustainable modes of transportation</li> <li>- Connected infrastructure</li> </ul>                                                                                                                 | <ul style="list-style-type: none"> <li>- New road infrastructure in good condition.</li> <li>- Traffic congestion</li> <li>- Insufficient infrastructure</li> </ul>                                                                                                                                                                                                               |

|                   |                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                      |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                   | <ul style="list-style-type: none"> <li>- Interconnected multimodal transportation</li> <li>- Flexible and reliable mobility</li> </ul>                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                      |
| Smart Environment | <ul style="list-style-type: none"> <li>- Sustainable resource management</li> <li>- Water management</li> <li>- Energy management</li> <li>- Waste management</li> <li>- Renewable energy</li> <li>- Green construction</li> <li>- Sustainable urban planning</li> <li>- Environmental protection</li> <li>- Pollution</li> </ul> | <ul style="list-style-type: none"> <li>- Natural resource consumption</li> <li>- Poor water and energy management</li> <li>- Complete absence of waste management</li> <li>- No recycling, rainwater optimization, or use of renewable resources</li> <li>- Environmental pollution</li> <li>- CO2 emissions</li> </ul>                              |
| Smart Living      | <ul style="list-style-type: none"> <li>- Security</li> <li>- Well-being</li> <li>- Health</li> <li>- Culture</li> <li>- Communicating infrastructures (smart buildings)</li> </ul>                                                                                                                                                | <ul style="list-style-type: none"> <li>- Lack of urban development management</li> <li>- Poor quality and accessibility of services provided</li> <li>- Absence of smart buildings</li> <li>- Housing shortage and inadequate conditions in some areas</li> <li>- Insufficient basic social services, especially for children and elderly</li> </ul> |

## 8. Potentials and Weaknesses Across Multiple Scales

In assessing the urban development of Chlef and the El-Hassania quarter, it is crucial to identify both the potentials and weaknesses across various scales. This evaluation provides a comprehensive understanding of the areas of strength that can be leveraged for future growth and the challenges that need to be addressed for sustainable development. The following table outlines the key potentials and weaknesses identified in Chlef and El-Hassania.

| Scale              | Potential                                                                                                                                                                                                                                                                                                                                                                                                                 | Weakness                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Territorial</b> | <ul style="list-style-type: none"> <li>- Significant forest heritage</li> <li>- Potable water connection: increased from 62% to 98% (1999-2021); sanitation from 60% to 90%.</li> <li>- Water allocation: improved from 70 liters/day (1999) to 180 liters/day (2021).</li> <li>- Chelif River: major waterway with Oued Fodda and Sidi Yakoub dams.</li> <li>- Advanced ICT: ADSL, 4G LTE, WIFI, WI MAX up to</li> </ul> | <ul style="list-style-type: none"> <li>- Seismic Risk: Chlef is classified in Zone III for seismic risk, necessitating robust infrastructure and planning to mitigate potential hazards and ensure the resilience of urban structures 11.</li> <li>- Lack of Comprehensive Vision: Despite the city's attractiveness and economic opportunities, there is a noticeable gap in the</li> </ul> |

|                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                              | <p>100 Mbps; 80% internet subscription; future FTTH upgrade.</p> <ul style="list-style-type: none"> <li>- Renewable energy: solar power for schools and mosques in Chlef, Kadiria, and Chatia.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <p>government's overarching vision for Chlef as a smart city. This lack of a comprehensive strategy may hinder sustainable urban development and infrastructure upgrades</p>                                                                                                         |
| <b>Municipality</b>                                          | <ul style="list-style-type: none"> <li>- Diverse topography including mountains, plains, valleys, and coastal regions.</li> <li>- Varied soils with fertile plains, rocky mountains, and sandy coastal areas.</li> <li>- Chelif River regulated by Oued Fodda and Sidi Yakoub dams, supported by two ports.</li> <li>- Population growth driven by post-1980 housing and rural-to-urban migration.</li> <li>- Strong workforce with low unemployment and significant employment levels.</li> <li>- Improved water infrastructure from 1999 to 2021, including increased connections and sanitation services.</li> <li>- Mediterranean sub-humid climate with balanced precipitation.</li> <li>- Strategic location with RN04 and RN19 highways and a 120-kilometer coastline.</li> <li>- Growing urbanization offering opportunities for tourism development.</li> </ul> | <ul style="list-style-type: none"> <li>- Classified in Zone III for seismic risk, necessitating robust infrastructure.</li> <li>- High population density due to rapid urbanization.</li> <li>- Climate extremes with hot summers and cold, rainy winters.</li> </ul>                |
| <b>Urban scale :<br/>Chlef city and El-Hassania district</b> | <ul style="list-style-type: none"> <li>- Strategic Location: Situated in southwest Chlef, El Hassania benefits from strategic connectivity and proximity to key landmarks, fostering further development opportunities.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>- Shortage of green areas, parks, and recreational spaces limits outdoor socialization and leisure activities for residents.</li> <li>- The absence of proper planning for public areas like bicycle lanes and pedestrian pathways</li> </ul> |

|                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                               | <ul style="list-style-type: none"> <li>- Infrastructure Development: The neighborhood features a dense road network, indicating potential for improved mobility and connectivity with proper planning and expansion.</li> <li>- The presence of a university hub and upcoming Cancer Treatment Center positions El Hassania as a potential hub for education and healthcare services.</li> <li>- Growth Opportunities: Ongoing housing and expansion projects offer opportunities for population growth, economic development, and urban revitalization.</li> </ul> | <ul style="list-style-type: none"> <li>hinders urban life quality and safety.</li> <li>- Despite a dense road network, El Hassania lacks new parcel divisions and bypass roads, exacerbating mobility challenges.</li> <li>- Limited Amenities: The scarcity of public amenities such as gardens and playgrounds reduces overall livability and well-being.</li> <li>- Some housing units show signs of deterioration, necessitating revitalization efforts and urban renewal for aesthetic and functional improvements.</li> </ul> |
| <b>Community Scale<br/>(Residents of El-Hassania Quarter)</b> | <ul style="list-style-type: none"> <li>- Conducting surveys among residents to assess the feasibility of an energy-autonomous smart district provides valuable insights for community engagement. Understanding residents' preferences guides sustainable initiatives.</li> </ul>                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>- Collaboration among government, private sectors, and community stakeholders faces challenges due to differing priorities and communication barriers. Overcoming these is crucial for unified sustainable development.</li> <li>- Public awareness gaps about energy-autonomous districts hinder resident engagement. Effective communication strategies are needed for active participation.</li> </ul>                                                                                    |

## **Conclusion:**

In conclusion, this chapter provides an extensive exploration of Chlef's urban dynamics, focusing particularly on the El-Hassania Quarter's progression towards energy-autonomous solutions. It employs a systematic approach involving thorough data collection, rigorous analysis, and evaluation based on Giffinger criteria to uncover the complexities of urban development and smartness in Chlef.

Emphasizing the significance of community engagement and collaboration among stakeholders, the chapter underscores the critical role of establishing a unified vision and resilient framework to propel Chlef towards its future as a smart city. The evaluation according to Giffinger criteria offers nuanced insights into Chlef's potential as a smart city, highlighting key strengths while identifying areas for improvement.

By addressing specific strengths and weaknesses observed in the El-Hassania Quarter, the chapter provides actionable considerations for sustainable growth and infrastructure enhancement. This strategic approach aims to enhance livability, resilience, and technological integration across Chlef, fostering a vibrant and inclusive urban environment.

In essence, this chapter serves as a roadmap for Chlef's transformation into a resilient and technologically advanced cityscape. By leveraging data-driven insights and fostering collaborative governance, Chlef endeavors to set new benchmarks in urban sustainability and quality of life in the region.



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## **CHAPTER V:**

# **Guiding the Transition: Actionable Frameworks for Smart Urban Life (the project)**

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1. Action Plan
2. Conceptual Plan for Achieving Energy Autonomy in El-Hassania District
3. Empowering El Hassania Quarter: Transitioning to a Smart Energy Autonomous District

### **Introduction:**

This Chapter unveils a transformative vision for El Hassania, propelling the district toward a future characterized by sustainability, efficiency, and community well-being.

This chapter serves as a strategic compass, guiding El Hassania on a path toward becoming a smart, energy-autonomous district that embodies the principles of innovation and environmental stewardship. By integrating advanced technologies and renewable energy sources, El Hassania aims to redefine urban living through a holistic approach that encompasses smart governance and smart environment initiatives.

As we delve into the actionable frameworks outlined in this chapter, it becomes evident that El Hassania's journey towards sustainability is not just a destination but a continuous evolution.

This chapter delves into the specifics of the rehabilitation and modernization of existing infrastructures, turning individual houses into green buildings through energy-efficient retrofits and renewable energy installations. The focus is on creating a self-sufficient district where energy needs are met through sustainable means, significantly reducing the carbon footprint. By retrofitting existing buildings with state-of-the-art insulation, energy-efficient windows, and advanced heating systems powered by biomass and biogas, El Hassania aims to become a model for other urban areas seeking to transition to sustainable living

Through comprehensive training programs for stakeholders and the implementation of key actions such as solar panels, biogas stations, and smart meters, the district is poised to revolutionize its energy production, distribution, and management systems.

In summary, this chapter lays the foundation for El Hassania's transformation into a smart, energy-autonomous district. By integrating renewable energy sources, advanced technological systems, and comprehensive community engagement, El Hassania is set to become a benchmark for sustainable urban development, offering a blueprint for other cities to follow in the quest for a smarter, greener future.

## 1. Action Plan:

To facilitate our transition towards becoming a smart energy-autonomous quarter, we have proposed a set of actions to be undertaken. The diagrams below outline the scale, tools, timeline, and stakeholders involved in the priority or most important action for each area addressed (smart governance, smart environment).

### 1.1 Smart Governance:

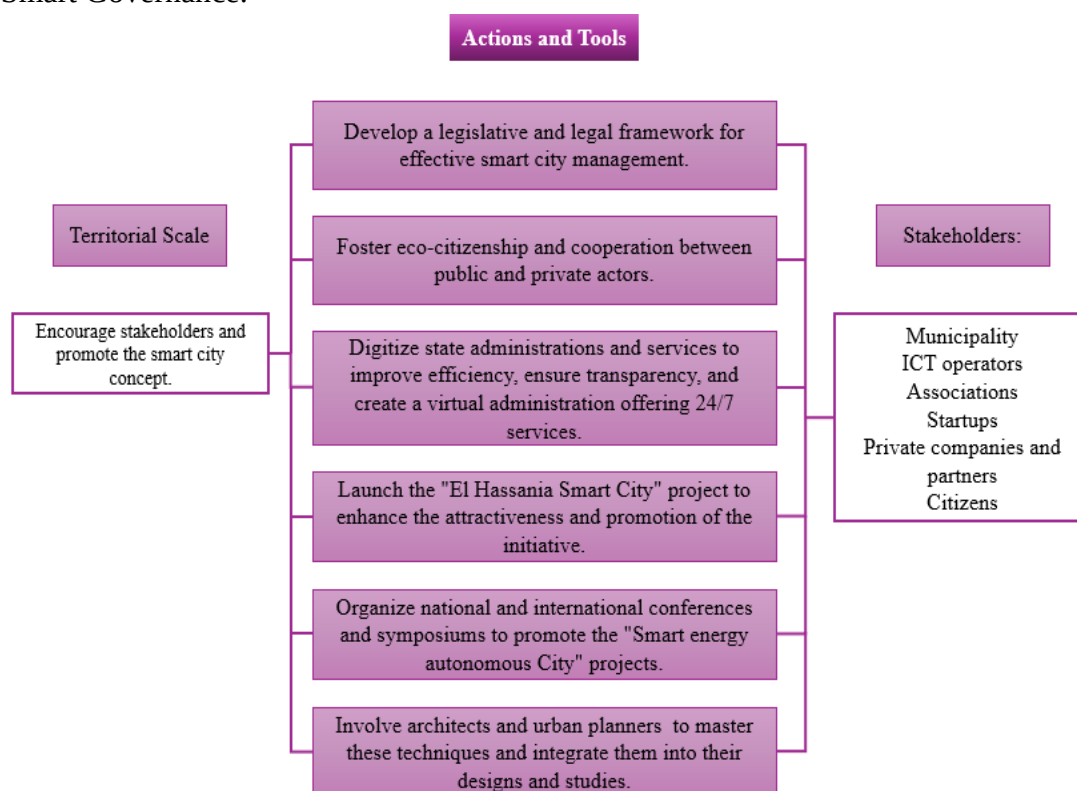


*Figure 48 Action Plan for a Smart Governance*

## 1.2 Smart Environment:

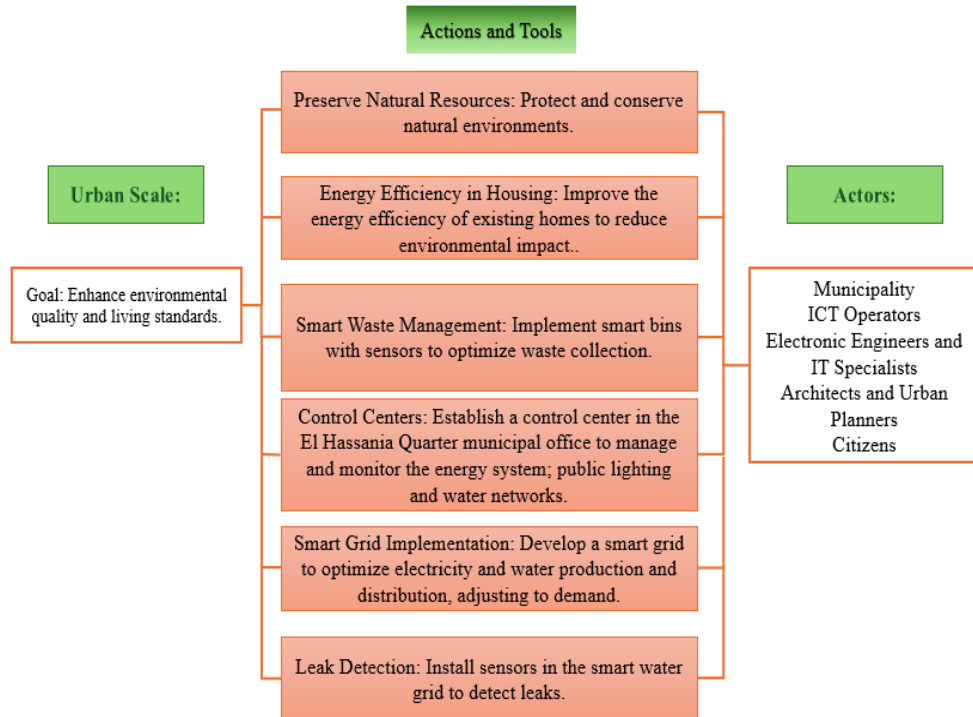


*Figure 49 Action Plan For Smart Environment*

## 1.3 Smart City in El Hassania: Training Experts and Citizens - A Necessary Step

The scarcity of training programs hinders the skill development of local authorities in the smart city domain. Beyond technical skills, managerial aspects are crucial.

### 1. Goals for Training Smart City Stakeholders (Experts, Citizens, etc.):

- ✓ **Define the Smart City:** Understand the concept, objectives, and specific projects related to a smart city.
- ✓ **Manage Technological and Societal Challenges:** Address the technological and societal issues linked to the smart city within our project framework.
- ✓ **Implement Technological Aspects:** Utilize and properly control the necessary systems, and address the interconnection of these systems.

- ✓ **Integrate Citizen Participation:** Develop participatory platforms, facilitate public debates, and ensure community involvement.
- ✓ **Prevent Privacy Risks:** Address the potential "Orwellian" risks associated with a connected city.

 **Actions to Transform El Hassania into a Smart, Energy-Autonomous District:**

- ✓ **Training Programs:** Develop comprehensive training programs for local authorities, experts, and citizens on smart city concepts and management.
- ✓ **Technological Systems:** Implement advanced technological systems for energy management, water distribution, and public lighting with integrated sensors for optimization.
- ✓ **Participatory Platforms:** Create platforms for citizen participation and engagement in decision-making processes.
- ✓ **Public Debates:** Organize public debates to discuss and address community concerns and ideas regarding smart city initiatives.
- ✓ **Privacy Safeguards:** Establish robust policies and safeguards to protect citizen privacy and prevent misuse of data.

By focusing on these training and implementation actions, El Hassania can effectively transition into a smart, energy-autonomous district, promoting sustainability, efficiency, and community well-being.

### 1.3 Urban Actions: Action Plan

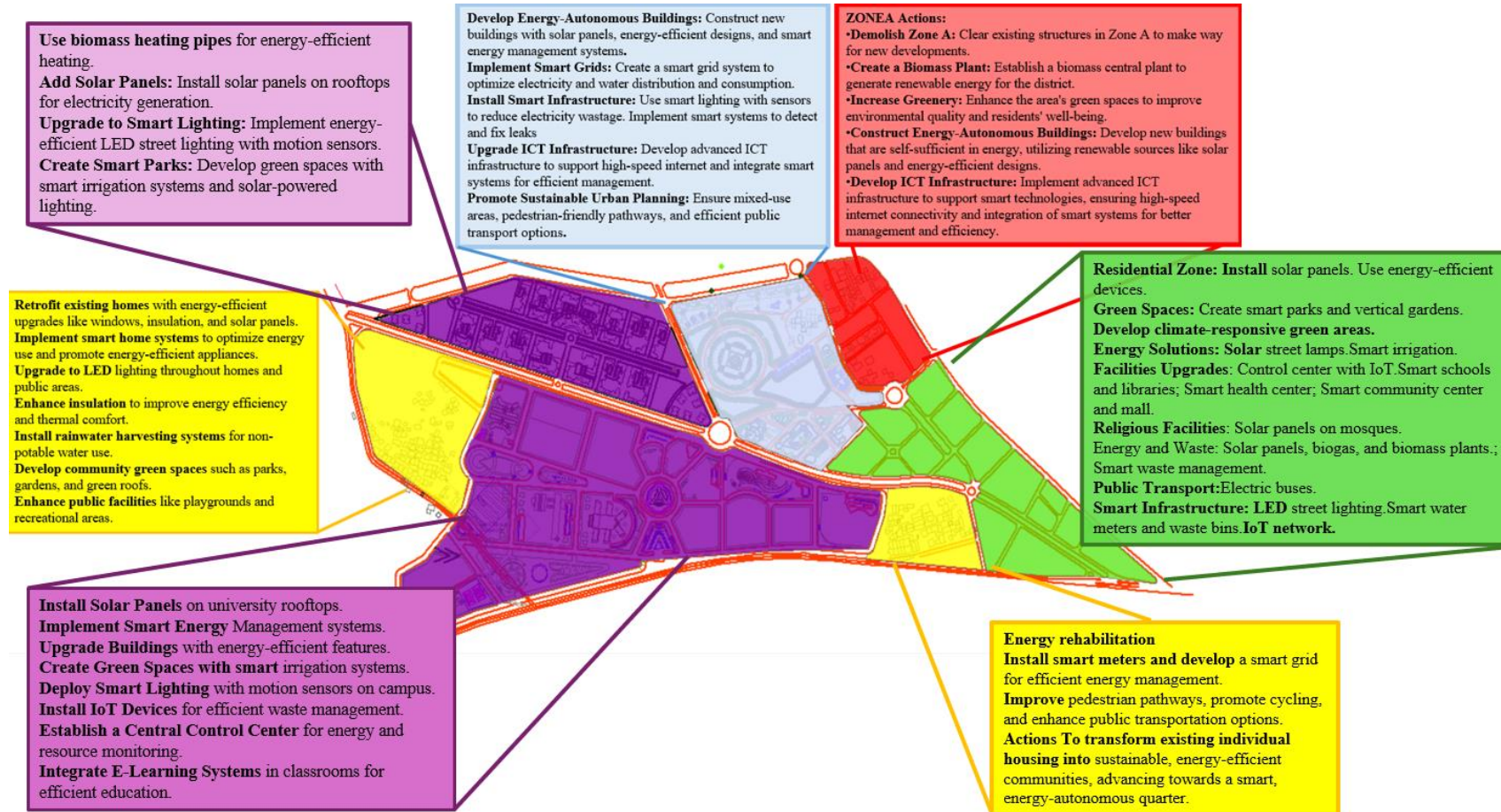


Figure 50 Action Plan; Source: Created By Author

## **2. Conceptual Plan for Achieving Energy Autonomy in El-Hassania District**

This section presents a detailed conceptual schema aimed at transforming the El-Hassania Quarter into a smart, energy-autonomous community. The schema outlines strategic elements designed to enhance energy production, distribution, and management within the district.

### **2.1 General Energetic Conceptual Schema:**

The conceptual energetic schema for the El-Hassania Quarter outlines a comprehensive plan to transform the district into a smart, energy-autonomous community. The schema integrates various elements to ensure efficient energy production, distribution, and management. Key components include:

-  **Individual Houses and Buildings:** Equipped with solar panels (PV) to harness solar energy. Energy-efficient designs and technologies to minimize consumption.
-  **Biogas Station:** Produces biogas from organic waste to supply energy for heating and electricity.
-  **Biomass Station:** Converts biomass into heat and electricity, supporting district heating systems.
-  **Gas Transportation Station:** Manages gas and electricity transportation to different parts of the district.
-  **Electric Vehicle (EV) Charging Stations:** Supports the adoption of electric vehicles with accessible charging points.
-  **Connected Communication Meters:** Smart meters for real-time monitoring and management of energy usage.
-  **Gas Back-Up Station:** Provides a backup gas supply to ensure energy reliability during peak demands or outages.
-  **Transmission Tower:** Facilitates the transmission of electricity across the district.
-  **Control Center:** Acts as the central hub for monitoring, managing, and optimizing all energy and infrastructure systems.
-  **Electricity Transport Network:** A grid to transport electricity generated from various sources to different locations.
-  **Biogas Transport Network:** Pipeline network to transport biogas from the production station to consumption points.
-  **Heat Transport Network:** Distributes heat generated from biomass and biogas stations to residential and commercial buildings.
-  **Electricity Distribution Network:** Ensures the distribution of electricity from the transport network to end-users efficiently.
-  **Gas Distribution Network:** Distributes gas from the transportation station to homes and businesses within the district.

This schema represents a synergistic approach to creating a resilient, energy-efficient, and sustainable urban environment in the El-Hassania Quarter, leveraging advanced technologies and renewable energy sources to meet the challenges of rapid urbanization.

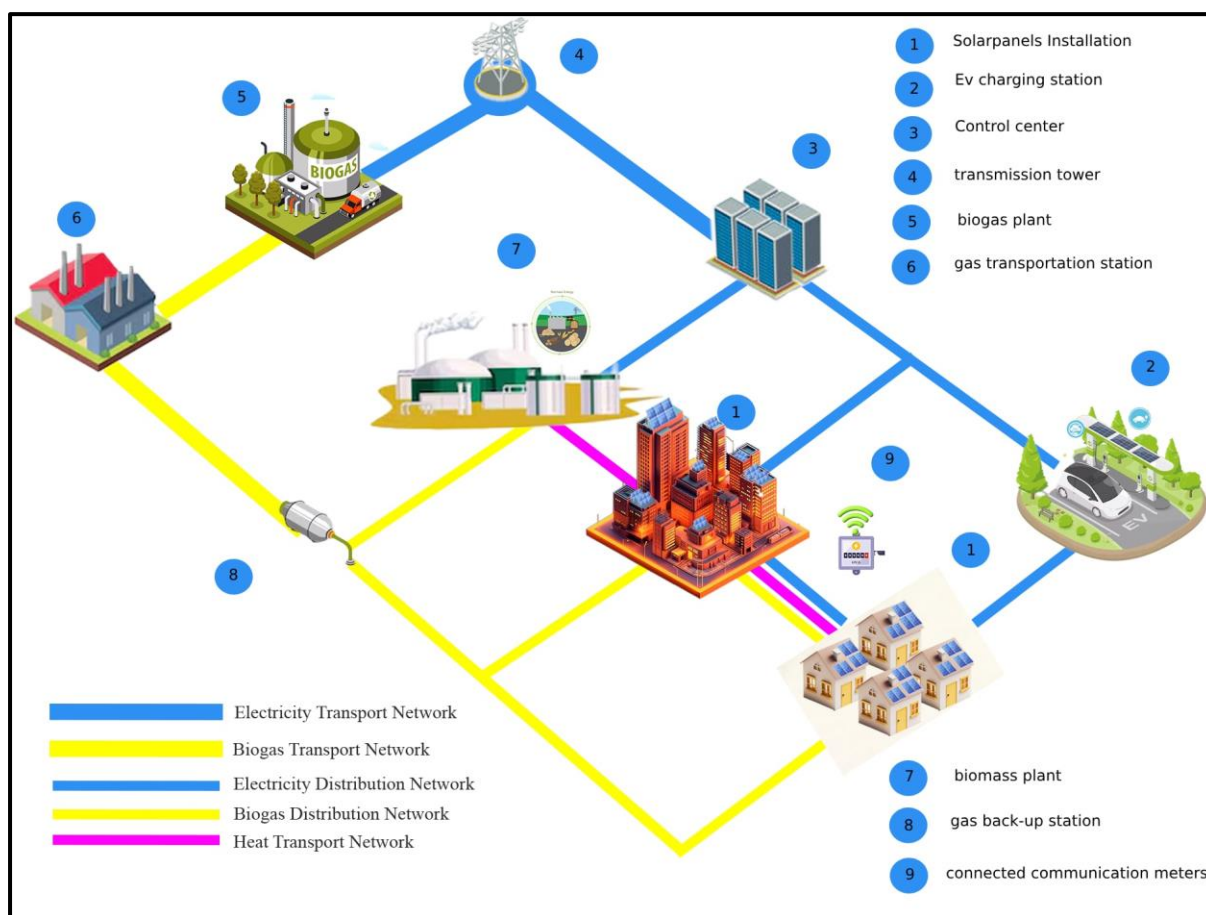


*Figure 51 Conceptual Energetic Schema*

*Source: Created By Author*

## 2.2 Conceptual Schema:

The conceptual plan for the project envisions transforming a residential zone into a smart and energy-autonomous community with integrated sustainable features across various sectors:

### Residential Zone:

- New housing structures, ranging from 7 to 9 floors, will be equipped with solar panels on rooftops to generate electricity.
- Apartments and buildings will be outfitted with energy-efficient devices to minimize energy consumption.

### Public and Green Spaces:

- Interactive parks will feature smart benches, energy-harvesting pathways, and biodiversity monitoring systems.
- Vertical and sensor-based gardens with automated irrigation systems will enhance community engagement.
- Climate-responsive public green spaces will include adaptive shading, smart irrigation, and innovative playgrounds for children..

**Energy Solutions:**

- Solar panels installed across various locations will generate electricity for the community.
- A Biogas Production Plant (BPP) will use anaerobic digestion to produce biogas from organic waste.
- A Biomass Central Heating Plant (BCHP) will provide district heating and hot water production.

**Waste Management:**

- Organic waste from households and commercial establishments will be collected through a network of collection points and containers, and then processed at the Biogas Production Plant (BPP) for biogas production.

**Smart Infrastructure:**

- Smart water meters and leak detection systems will optimize water management.
- IoT-enabled waste bins will monitor fill levels and optimize waste collection routes.
- A comprehensive IoT network will monitor and manage city infrastructure and services to enhance operational efficiency and sustainability.

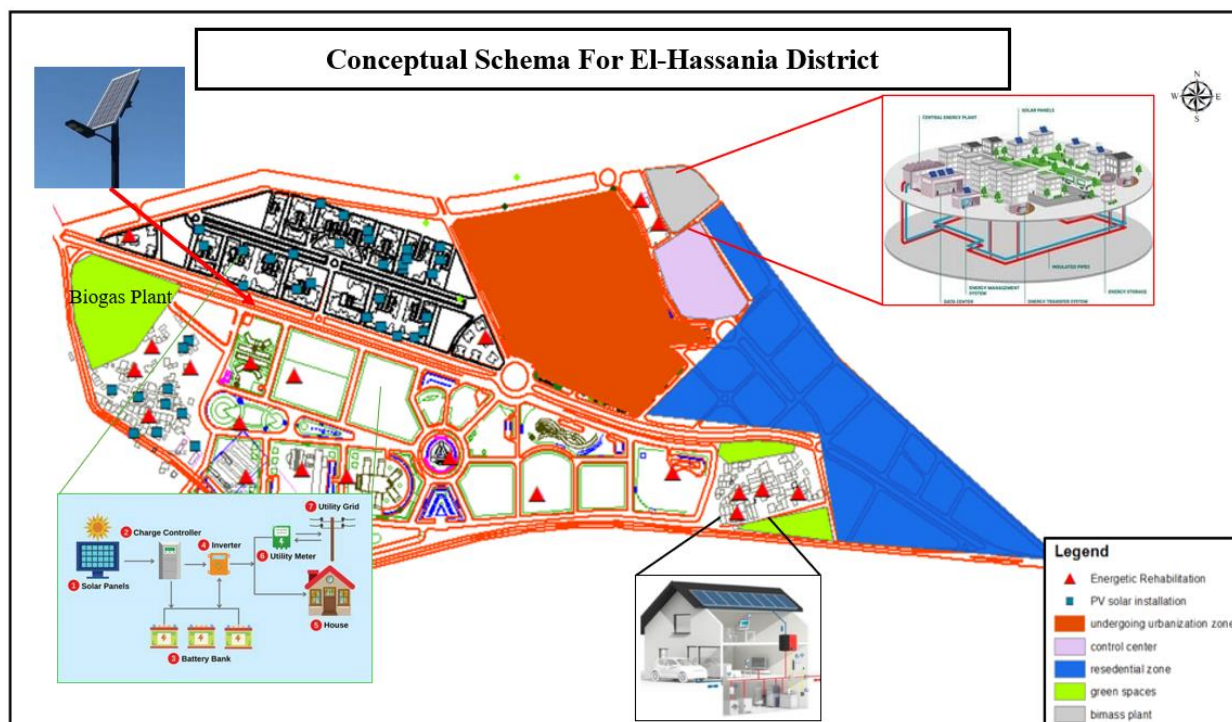


Figure 52 Conceptual Schema

Source: Created By Author

### **3. Empowering El Hassania Quarter: Transitioning to a Smart Energy Autonomous District**

This section outlines the plan to transform El Hassania Quarter into a smart, energy-autonomous district. By integrating renewable energy sources, smart technologies, and sustainable practices, the goal is to create a community that is both efficient and self-sufficient. The initiative aims to improve the quality of life for residents while setting a benchmark for future urban developments.

#### **3.1 population Projections:**

To define the housing and amenities program, it is essential to determine the maximum number of housing units and population that the site can accommodate. To obtain these figures, we have adopted a specific approach:

##### **3.1.1 Approach:**

##### **Maximum Accommodation Capacity:**

- **Area of Study:** 212 Hectares
- **Number of Existing Housing Units:** 320 Units
- **Current Population:** 2,240 Inhabitants
- **Number of unhabituated Housing Units:** 2000Units
- **Occupancy Rate per Unit:** 5 Inhabitants/Unit
- **Projected housing :** 1500 Units
- **Projected Population:** 17500 Inhabitants

**Total Projected Population:** 19740 Inhabitants

#### **3.2 The program**

| <b>Program</b>          | <b>Type</b> | <b>Description</b>                                                                                                                                                     | <b>Number of units</b> | <b>Area (Hectares)</b> |
|-------------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------------------|
| <b>Residential Zone</b> | Housing     | 7 to 9 floors building; appartements install solar panels on rooftops of existing houses for electricity production. Buildings equipped with energy-efficient devices. | 1500                   | 53                     |

|                                 |                        |                                                                                                                                                                                                                                                                                                                                             |    |     |
|---------------------------------|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----|
| <b>Public and green spaces</b>  | Park                   | Interactive parks with smart benches, energy-harvesting pathways, and biodiversity monitoring systems.                                                                                                                                                                                                                                      | 01 | 0.8 |
|                                 | Gardens                | Vertical and sensor-based gardens with automated irrigation and community engagement features.                                                                                                                                                                                                                                              | 03 | 1.5 |
|                                 | Public green spaces    | Climate-responsive spaces with adaptive shading and irrigation, and smart playgrounds for children.                                                                                                                                                                                                                                         | -  | 4   |
|                                 | <b>Energy Solution</b> | Solar street lamps for lighting parks and gardens. Smart irrigation systems controlled by soil sensors.                                                                                                                                                                                                                                     |    |     |
| <b>Administrative equipment</b> | Control center         | The control center serves as the heart of the smart and energy-autonomous city, a centralized database and control hub for monitoring, managing, and optimizing all city infrastructure and services. Equipped with advanced IoT and AI technologies, the control center enables efficient resource allocation, predictive maintenance, and | 01 | 2   |

|                            |                  |                                                                                                                                                                            |    |     |
|----------------------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----|
|                            |                  | quick response to any urban issues.                                                                                                                                        |    |     |
|                            | Primary school   | Smart primary school with 12 classes, integrated e-learning systems                                                                                                        | 06 | 1.5 |
|                            | Middle school    | Smart middle school with 15 classes, integrated e-learning systems                                                                                                         | 04 | 2.3 |
|                            | High school      | Smart high school with advanced technology and e-learning systems                                                                                                          | 02 | 2.1 |
|                            | Public library   | Digital public library with access to e-books and online resources                                                                                                         | 01 | 2   |
|                            | Health center    | Smart health center with telemedicine facilities with 10 beds                                                                                                              | 01 | 2   |
| <b>Recreational</b>        | Community center | Smart community center with IoT devices for efficient management                                                                                                           | 01 | 1   |
|                            | mall             | Smart shopping mall with energy-efficient systems and smart management. Solar roofs and energy management systems to reduce carbon footprint and increase energy autonomy. | 01 | 1   |
| <b>Religious equipment</b> | Mosque           | With solar panels installed on rooftops                                                                                                                                    | 01 | 0.7 |

|                              |                                                                          |                                                                                                                                                                                                                           |    |   |
|------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|---|
|                              |                                                                          | for electricity generation                                                                                                                                                                                                |    |   |
| <b>Energy</b>                | Solar Power Generation                                                   | Solar panels installed on rooftops on various locations for electricity generation                                                                                                                                        | -  | - |
|                              | Biogas Production Plant (BPP)                                            | Biogas plant for biogas production                                                                                                                                                                                        | 01 | 1 |
|                              | Biomass Central Heating Plant (BCHP)                                     | Biomass central heating plant for district heating and hot water production                                                                                                                                               | 01 | 1 |
| <b>waste management</b>      | The BPP uses anaerobic digestion to break down organic waste into biogas | Collect the organic waste from households and commercial establishments through a network of collection points and containers. Then the organic waste is transported to the Biogas Production Plant (BPP) for processing. |    | 2 |
| <b>Public Transportation</b> | Public Transportation System with Electric Buses (PTSEB)                 | Public transportation system with electric buses, equipped with real-time tracking and smart scheduling applications                                                                                                      | -  | 1 |
| <b>Smart Infrastructure</b>  | Smart Lighting                                                           | Energy-efficient LED street lighting with motion sensors and                                                                                                                                                              | -  | - |

|  |                                  |                                                                                        |   |   |
|--|----------------------------------|----------------------------------------------------------------------------------------|---|---|
|  |                                  | remote control capabilities                                                            |   |   |
|  | Smart Water Management           | Smart water meters and leak detection systems for efficient water use and management   | - | - |
|  | Smart Waste Management           | IoT-enabled waste bins that monitor fill levels and optimize collection routes         | - | - |
|  | Internet of Things (IoT) Network | Comprehensive IoT network for monitoring and managing city infrastructure and services | - | - |

### 3.3 Overview of the Project

In this part, we delve into an overview of the ambitious project aimed at transforming El Hassania Quarter into a smart, energy-autonomous district. This section outlines the strategic initiatives and transformative steps envisioned to achieve sustainable development and enhanced livability within the community.

### **3.3.1 Transforming AADEL Collective Housing into Sustainable Smart Buildings**

undertake an energy rehabilitation initiative for existing collective housing in the AADEL collective housing, transforming them into sustainable green buildings.

This involves enhancing energy efficiency through the installation of solar photovoltaic panels on rooftops and parking areas.

Additionally, biomass and biogas systems will be integrated to provide heating and energy generation, aiming to create a more environmentally friendly and energy-independent community.



*Figure 53 A Realistic Visualisation For AADEL Collective Housing*

*Source: Created by Author*

### **3.2.2 Retrofitting and Solar Integration for Existing Individual Houses**

The project entails a comprehensive approach to improve energy efficiency in existing individual houses within the district.

By retrofitting these homes with modern technologies and installing solar panels on rooftops, the initiative aims to minimize energy consumption and reliance on traditional power grids.

This transformation not only contributes to environmental sustainability by reducing carbon emissions but also enhances the resilience of the community to fluctuating energy costs and disruptions.



*Figure 54 Simulation of PV panels Installation in Existing Individual House at El-Hassania*

*Source: Simulated by Author*

### **3.3.3 Housing:**

The residential zone will feature 7 to 9-floor apartment buildings equipped with solar panels on rooftops to produce electricity. These buildings will also be outfitted with energy-efficient devices, ensuring a sustainable living environment for residents. The housing development aims to accommodate approximately 1500 units across an estimated area of 25 to 30 hectares.



*Figure 55 A Realistic Visualisation for The Housing Program Source: Created By Author*

### **3.3.4 Public and Green Spaces**

- **Park:**

An interactive park will be created, featuring smart benches, energy-harvesting pathways, and biodiversity monitoring systems. This park will offer residents a technologically advanced recreational area while promoting environmental sustainability.

- **Gardens:**

Vertical and sensor-based gardens with automated irrigation systems will be developed to enhance green spaces. These gardens will encourage community engagement and improve the environmental quality of the district.

- **Public Green Spaces:**

Climate-responsive public green spaces will be established, incorporating adaptive shading and irrigation systems. These spaces will also feature smart playgrounds for children, providing a safe and sustainable environment for all age groups.

- **Energy Solutions:**

The district will implement solar street lamps to illuminate parks and gardens. Smart irrigation systems controlled by soil sensors will optimize water usage and ensure the health of green spaces.

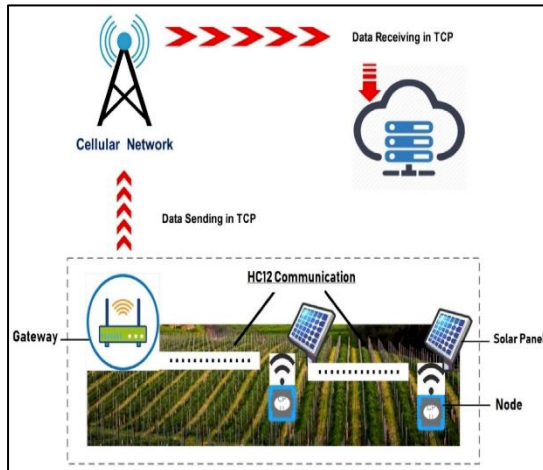


Figure 56 Smart Irrigation System diagram Source: [www.tpsearchtool.com](http://www.tpsearchtool.com)



Figure 57 Garden Visualisation With Energy Harvesting Pathways

Source: Created by Author + Improved By AI

### 3.3.5 Administrative Equipment

- **Control Center:**

The control center will serve as the core of the smart and energy-autonomous city. This centralized hub will monitor, manage, and optimize all city infrastructure and services, utilizing advanced IoT and AI technologies for efficient resource allocation and quick response to urban issues.



Figure 58 control center visualisation  
Source: created by author

### 3.3.6 Educational Facilities:

- **Primary School:** Six smart primary schools, each with 12 classes and integrated e-learning systems, will be established.
- **Middle School:** Four smart middle schools, each with 15 classes and integrated e-learning systems, will be developed.
- **High School:** Two smart high schools will be built, featuring advanced technology and e-learning systems.

- **Public Library:**

A digital public library will be constructed, providing access to e-books and online resources, promoting digital literacy among residents.

- **Health Center:**

A smart health center equipped with telemedicine facilities and 10 beds will be set up to cater to the healthcare needs of the community.

### 3.3.7 Recreational Facilities

- **Community Center:**

A smart community center will be developed, featuring IoT devices for efficient management of community activities and resources.

- **Shopping Mall:**

A smart shopping mall will be constructed, incorporating energy-efficient systems and smart management practices. Solar roofs and energy management systems will be used to reduce the carbon footprint and increase energy autonomy.

### 3.3.8 Religious Equipment

#### **Mosque:**

A mosque with solar panels installed on rooftops will be built, ensuring that the religious facility contributes to the district's energy generation efforts.

### 3.3.9 Energy Solutions

#### **Solar Power Generation:**

Solar panels will be installed on rooftops throughout the district to generate electricity.

#### **Biogas Production Plant (BPP):**

A biogas plant will be established to produce biogas from organic waste.

#### **Biomass Central Heating Plant (BCHP):**

A biomass central heating plant will be constructed for district heating and hot water production.



*Figure 59 Biomass Plant Visualisation*

*Source: Created By Author*

### **3.3.10 Waste Management**

The BPP will use anaerobic digestion to break down organic waste into biogas. Organic waste will be collected from households and commercial establishments through a network of collection points and containers, then transported to the BPP for processing.

### **3.3.11 Public Transportation**

#### **Public Transportation System with Electric Buses (PTSEB):**

A public transportation system featuring electric buses with real-time tracking and smart scheduling applications will be introduced to enhance mobility within the district.

### **3.3.12 Smart Infrastructure**

- **Smart Lighting:** Energy-efficient LED street lighting with motion sensors and remote control capabilities will be implemented to improve energy use and enhance security.
- **Smart Water Management:**  
Smart water meters and leak detection systems will be installed to ensure efficient water use and management.
- **Smart Waste Management:**  
IoT-enabled waste bins will be used to monitor fill levels and optimize collection routes, ensuring efficient waste management practices.
- **Internet of Things (IoT) Network:**  
A comprehensive IoT network will be established to monitor and manage city infrastructure and services, enabling the smart city to function efficiently and sustainably.

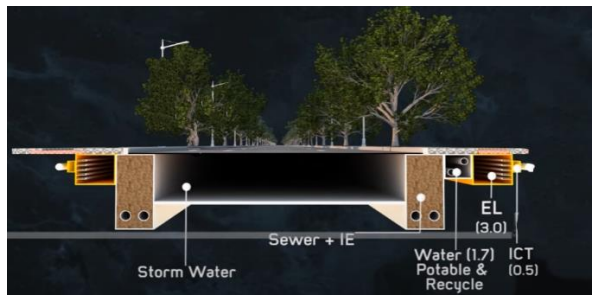


*Figure 61 Secondary Road*

*Source: Created By Author*



*Figure 60 Tertiary Road*

*Source: Created By Author*

## The Project

## **Conclusion**

In conclusion, Chapter 05 serves as a pivotal chapter in El Hassania's quest to transition into a smart, energy-autonomous district that exemplifies the values of sustainability and progress. By embracing a forward-thinking approach that combines technological innovation with community empowerment, El Hassania is laying the groundwork for a future where energy autonomy and environmental consciousness go hand in hand.

The synergistic implementation of the conceptual plan outlined in this chapter underscores the district's commitment to creating a vibrant, sustainable urban environment that meets the needs of its residents and stakeholders.

As El Hassania embarks on this transformative journey, it is essential to nurture a culture of collaboration, inclusivity, and forward momentum.

By staying true to its vision of smart urban living and leveraging the power of innovation, El Hassania has the potential to not only shape its destiny but also inspire other communities to embrace sustainable practices and embrace a future where technology and sustainability converge for the greater good.



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## General Conclusion

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## General conclusion

This research explores the integration of energy-autonomous quarters within the unique urban context of El-Hassania quarter in Chlef, Algeria. The El-Hassania quarter provides a compelling backdrop for investigating energy autonomy amidst Algeria's rapid urbanization. The study was initiated to address the complexities and opportunities associated with enhancing energy autonomy in urban areas. By examining current energy infrastructure, consumption patterns, and community dynamics in El-Hassania, this research aimed to identify barriers to and enablers of successful implementation of energy-autonomous quarters.

The hypothesis guiding this research posited that implementing innovative technologies and strategies could effectively overcome obstacles to energy autonomy in urban areas of Algeria, such as Chlef. It suggested that practical deployment of these technologies, particularly in quarters like El-Hassania, would not only enhance energy efficiency but also increase community resilience and improve environmental sustainability, thereby reshaping sustainable urban living paradigms both locally and globally. The primary obstacles identified were infrastructural deficiencies and regulatory constraints rather than technological limitations.

Qualitative interviews with key stakeholders “local government officials, community leaders, and residents” provided nuanced insights into perceptions and attitudes towards energy autonomy. Stakeholders expressed varying levels of awareness and support for sustainable practices, with concerns predominantly centered around initial costs and technological reliability.

Infrastructure deficiencies, such as outdated grids and inadequate waste management systems, were highlighted as significant obstacles. Regulatory challenges, including bureaucratic processes and inconsistent policies, further complicated the implementation of innovative energy solutions. However, there was notable openness among local leadership to pilot projects and collaborative efforts aimed at enhancing energy autonomy and improving urban livability.

Quantitative surveys complemented these qualitative findings by quantifying specific aspects of energy usage and community readiness. Analysis of energy consumption patterns revealed peak demand periods, suggesting opportunities for implementing load balancing strategies. Residents demonstrated a moderate to high willingness to adopt energy-efficient technologies and renewable energy sources, contingent upon affordability and reliability. Mixed levels of satisfaction were reported regarding existing infrastructure, with concerns primarily focused on reliability and environmental impact.

Looking forward, future research should focus on enhancing stakeholder engagement to foster local acceptance and participation in energy-autonomous initiatives. Exploring the integration of emerging technologies such as blockchain for energy management and

artificial intelligence for predictive analytics in urban planning could further optimize sustainability and resilience efforts. Longitudinal studies are recommended to monitor the long-term impact of energy-autonomous solutions on urban resilience and sustainability metrics.

Finally, this study contributes a comprehensive framework for understanding and implementing energy-autonomous solutions in urban environments. By integrating interdisciplinary methodologies and leveraging advanced technological tools, the research addresses immediate challenges in El-Hassania and provides scalable solutions applicable to global urbanization challenges. The insights derived from El-Hassania Quarter serve as a practical guide for leveraging innovation and community engagement towards sustainable urban development in Algeria and beyond.

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## **Annex n° 01: The Survey**

**People's Democratic Republic of Algeria**  
**Ministry of Higher Education and Scientific Research**  
**Hassiba Ben Bouali University of CHLEF**  
**Faculty of Civil Engineering and Architecture**  
**Department of Architecture**

As part of the preparation of a research thesis titled "Towards a Smart City: The Challenges of an Energy-Autonomous District – Case Study: El-Hassania, Chlef" (for the Master's degree in Urban Engineering), this questionnaire is intended for the residents of the El-Hassania neighborhood. We kindly ask you to complete our questionnaire, assuring you that your anonymity and the confidentiality of your data will be maintained. Our research is solely for educational and academic purposes. Thank you in advance for your participation.

### **1. Personal Information**

1. Sex

☐ male ☐ female

2. Age group

☐ 15-29 years old ☐ 30-49 years old ☐ 50-69 years ☐ 70 years and above

3. What are you doing with your life?

☐ student ☐ laborer ☐ unemployed ☐ retired

4. Do you have a computer at home (computer/laptop)?

☐ yes ☐ no

### **2. Internet Connectivity and Usage:**

5. Do you currently have an Internet connection at home?

☐ yes ☐ no

6. Which of these devices do you use to connect to the Internet?

☐ computer (PC) ☐ laptop ☐ the mobile phone is connected to 4G or 5G

7. How much do you use the Internet?

☐ rarely ☐ once a week ☐ less than an hour a day ☐ More than an hour a day

8. How many people are in your house?

☐ 2 to 4 people ☐ 4 to 6 people ☐ 6 to 8 people ☐ more than 8 people

9. Are everyone online?

☐ yes ☐ no

10. Do you consider the Internet a necessary tool in your daily life?

☐ yes ☐ no

### **3. Online Services and Digitalization:**

11. Do you use online payment/mobility apps (yeser/utusa chlef)?

☐ yes ☐ no

12. How often do you use online services?

☐ never ☐ annually ☐ monthly ☐ Daily

13. What do you think about converting management and services to the digital system?

☐ yes, I think it's useful ☐ no, it is not useful

### **4. Smart Technology and Smart Cities:**

14. Do you know what smart things are?

☐ yes ☐ no

15. Do you have something smart (Watch, drone, car, smartphone...)?

☐ yes ☐ no

16. Would you agree to put smart devices in your home?

☐ yes ☐ no

17. Do you know what a smart city is?

☐ yes

☐ no

18. Smart cities mean cities that use technology, tools, and modern techniques to enhance the standard of life and well-being of their citizens, provide them with the best quality services, and solve the problems they face, by collecting data in modern ways, then analyzing it and acting on it, including traffic and air quality. Water and energy consumption.

### 5. Renewable Energy:

19. Do you know what renewable energies are?

☐ yes

☐ no

20. Do you know about any of the following forms of renewable energy that have been used in your local environment before?

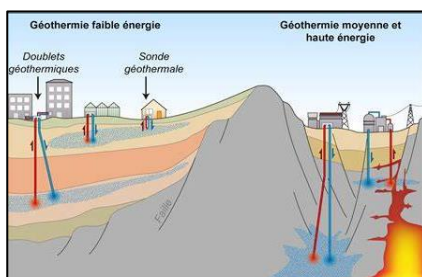
☐ solar energy



☐ Wind Energy



☐ Geothermal energy



☐ Bioenergy



☐ others

21. Do you agree to have your home equipped with renewable energy systems?

☐ yes

☐ no

22. Do you have prior knowledge about energy-independent living?

☐ yes

☐ no

23. Energy independent neighborhoods are areas or neighborhoods that are able to meet their basic energy needs from local renewable energy sources completely or almost completely, without relying on the public electrical grid. These neighborhoods include the use of renewable energy sources such as solar, wind, water, and geothermal energy, in addition to applying energy efficiency and energy storage technologies.

24. After knowing what smart, energy-independent neighborhoods are

Would you prefer your neighborhood to be a smart, independent neighborhood that produces energy using renewable energy sources?

☐ yes

☐ no

## **Annex n° 02: Interview with an Architect at URBAB and Technical Service Employee (Urban Planning) At the Municipality :**

### **Current Urban Planning Challenges:**

- 1) What are the primary urban planning challenges that Chlef city faced currently ?  
.....

### **Future of Urban Planning:**

- 2) How do you foresee the evolution of urban planning in Chlef over the next decade?  
.....

### **Integration of Smart Technologies:**

- 3) What are your perspectives on integrating smart technologies into current urban projects in Chlef?  
.....

### **Experience with Renewable Energies:**

- 4) Have you been involved in projects integrating renewable energies or developing energy-autonomous quarters? if yes, could you provide the details?  
.....

### **Obstacles to Smart and Energy-Autonomous Districts:**

- 5) From your viewpoint, what are the major obstacles to implementing smart and energy-autonomous districts in Chlef?  
.....

### **Recommendations for Smart Development:**

- 6) What specific measure would you recommend fostering the development of smart neighborhoods in Chlef?  
.....

### **Collaboration Among Urban Stakeholders:**

- 7) How do you perceive the collaboration among different urban stakeholders (government; private sectors; citizens) in realizing smart city initiatives in Chlef?  
.....

## Abstract:

As urbanization intensifies, the future of cities has become a significant concern, prompting experts and policymakers to seek effective theoretical and practical methods for sustainable urban development. One of the most promising approaches involves leveraging the digital revolution and the latest innovations in Information and Communication Technologies (ICTs). Smart cities emerge as viable solutions to urban challenges by ensuring sustainability.

This research focuses on the transformation of El Hassania Quarter in Chlef into an energy-autonomous smart district. The primary objective is to understand the concept of "smart cities" and identify the conditions, methods, and tools necessary for this urban transition. The study aims to achieve sustainable development, particularly in the areas of smart governance, smart environment, and smart mobility. By integrating renewable energy systems, advanced infrastructure, and community engagement strategies, the research outlines a comprehensive approach to enhancing urban living.

The findings demonstrate that with a blend of technological innovation and community involvement, urban districts can achieve significant progress in energy autonomy and environmental consciousness, setting a precedent for other urban areas.

**Key words:** Smart city – Energy Autonomy – Urban transition – Smart governance – Smart environment – Renewable Energy

## المخلص:

مع تزايد التوسع الحضري، أصبحت مستقبل المدن من القضايا البارزة التي تستدعي انتباه الخبراء وصناع السياسات للبحث عن الأساليب النظرية والعملية الفعالة لتحقيق التنمية الحضرية المستدامة. ومن بين الأساليب الواعدة التي تعتمد على الثورة الرقمية وآخر الابتكارات في تكنولوجيا المعلومات والاتصالات. تعتبر المدن الذكية حلولاً فعالة للتحديات الحضرية من خلال ضمان الاستدامة.

يركز هذا البحث على تحويل حي الحسنية في الشلف إلى حي ذكي مكثف ذاتياً بالطاقة. الهدف الرئيسي هو فهم مفهوم "المدن الذكية" وتحديد الشروط والأساليب والأدوات اللازمة لتحقيق هذا الانتقال الحضري. يهدف البحث إلى تحقيق التنمية المستدامة، خصوصاً في مجالات الحكم الذكي والبيئة الذكية والتنقل الذكي. من خلال دمج أنظمة الطاقة المتجددة والبنية التحتية المتقدمة واستراتيجيات المشاركة المجتمعية، يقدم البحث نهجاً شاملاً لتعزيز الحياة الحضرية.

تُظهر النتائج أنه من خلال مزيج من الابتكار التكنولوجي والمشاركة المجتمعية، يمكن للأحياء الحضرية تحقيق تقدم كبير في الاكتفاء الذاتي بالطاقة والوعي البيئي، مما يشكل نموذجاً يُحتذى به للمناطق الحضرية الأخرى.

**الكلمات المفتاحية:** المدينة الذكية – استقلالية الطاقة – التحول الحضري – الحوكمة الذكية – البيئة الذكية – الطاقة المتجددة.

## Résumé:

Avec l'intensification de l'urbanisation, l'avenir des villes est devenu une préoccupation majeure, incitant les experts et les décideurs à rechercher des méthodes théoriques et pratiques efficaces pour le développement urbain durable. Une des approches les plus prometteuses consiste à exploiter la révolution numérique et les dernières innovations en matière de technologies de l'information et de la communication (TIC). Les villes intelligentes apparaissent comme des solutions viables aux défis urbains en assurant la durabilité.

Cette recherche se concentre sur la transformation du Quartier El Hassania à Chlef en un district intelligent autonome en énergie. L'objectif principal est de comprendre le concept de "villes intelligentes" et d'identifier les conditions, méthodes et outils nécessaires à cette transition urbaine. L'étude vise à atteindre le développement durable, notamment dans les domaines de la gouvernance intelligente, de l'environnement intelligent et de la mobilité intelligente. En intégrant des systèmes d'énergie renouvelable, des infrastructures avancées et des stratégies d'engagement communautaire, la recherche propose une approche globale pour améliorer la vie urbaine.

Les résultats montrent qu'avec un mélange d'innovation technologique et de participation communautaire, les quartiers urbains peuvent réaliser des progrès significatifs en autonomie énergétique et en conscience environnementale, établissant un précédent pour d'autres zones urbaines.

**Mots-clés :** Ville intelligente – Autonome en Energie– Transition urbaine – Gouvernance intelligente – Environnement intelligent – Energie Renouvelable