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THE VIRTUALITY OF INTELLIGENT CITIES - THE ROAD TO HYBRIDIZING OUR NEW CITIES

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Abstract

The incorporation IoT into our social systems and the digitization of our everyday life has become the new norm for societies worldwide. This study posits that digitization should apply to our cities as well. The digital aspect of technology is not always tangible – even in the figurative sense of grasping a concept – and its allure lies in this virtual aspect. That is the starting point of discussion in this paper – the virtuality of intelligent cities, the intangible forces that make these new cities smart, and how said forces can be incorporated to create new smart hybrid cities that also aim to be intelligent, connected, and efficient. This research paper was designed to first set a strong theoretical base, which includes how the Circular City Actions CCA assessment framework works. This framework is applied to the three virtual methods, Sharing Economy, Smart Parking, and Virtual Power Plants VPP, as well as an international case study, the VPP in South Australia. The CCA framework was then applied to the data gathered for the local case study, the New Administrative Capital NAC in Egypt, which was chosen because it is the largest smart city being constructed currently in Egypt right now. Since it is still not fully operational, the data collected was based on governmental plans, proposals, and published papers about the city released within the last 5 years. After theoretically incorporating the proposed virtual methods into the NAC's plans and reapplying the assessment framework, the results were greatly improved in different aspects. This study made it clear that the NAC has a strong hypothetical foundation to become an intelligent connected city, but there were some missed opportunities of incorporating virtual intelligent solutions to be implemented at different levels as the three proposed in this paper to reach its goal.

Keywords

Smart virtual cities, intelligent hybrid cities, IoT, digital twins, circular city actions framework.

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ABSTRACT

The incorporation IoT into our social systems and the digitization of our everyday life has become the new norm for societies worldwide. This study posits that digitization should apply to our cities as well. The digital aspect of technology is not always tangible – even in the figurative sense of grasping a concept – and its allure lies in this virtual aspect. That is the starting point of discussion in this paper – the virtuality of intelligent cities, the intangible forces that make these new cities smart, and how said forces can be incorporated to create new smart hybrid cities that also aim to be intelligent, connected, and efficient. This research paper was designed to first set a strong theoretical base, which includes how the Circular City Actions CCA assessment framework works. This framework is applied to the three virtual methods, Sharing Economy, Smart Parking, and Virtual Power Plants VPP, as well as an international case study, the VPP in South Australia. The CCA framework was then applied to the data gathered for the local case study, the New Administrative Capital NAC in Egypt, which was chosen because it is the largest smart city being constructed currently in Egypt right now. Since it is still not fully operational, the data collected was based on governmental plans, proposals, and published papers about the city released within the last 5 years. After theoretically incorporating the proposed virtual methods into the NAC's plans and reapplying the assessment framework, the results were greatly improved in different aspects. This study made it clear that the NAC has a strong hypothetical foundation to become an intelligent connected city, but there were some missed opportunities of incorporating virtual intelligent solutions to be implemented at different levels as the three proposed in this paper to reach its goal.

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ملخص

أصبح دمج إنترنت الأشياء في أنظمتنا الاجتماعية ورقمنة حياتنا اليومية هو المعيار الجديد للمجتمعات في جميع أنحاء العالم. تفترض هذه الدراسة أن الرقمنة يجب أن تنطبق على مدننا أيضًا. لا يكون الجانب الرقمي للتكنولوجيا ملموسًا دائمًا - حتى بالمعنى المجازي لفهم تلك الفكرة - وتكمن جاذبيته في هذا الجانب الافتراضي. هذه هي نقطة البداية للمناقشة في هذه الورقة البحثية - افتراضية المدن الذكية، والقوى غير الملموسة التي تجعل هذه المدن الجديدة ذكية، وكيف يمكن دمج القوى المذكورة لإنشاء مدن ذكية مختلطة جديدة تهدف أيضًا إلى أن تكون ذكية ومتصلة وفعالة. تم تصميم هذه الورقة البحثية لوضع قاعدة نظرية قوية أولاً، والتي تتضمن فهم كنه إطار العمل للتقييم الدائري لإجراءات المدينة أو ما يسمى CCA. يتم تطبيق هذا الإطار على الطرق الافتراضية الثلاث، اقتصاد المشاركة، المواقف الذكية للسيارات، ومحطات الطاقة الافتراضية، بالإضافة إلى دراسة حالة دولية وهى محطة الطاقة الافتراضية في جنوب أستراليا. تم بعد ذلك تطبيق إطار عمل CCA على البيانات التي تم جمعها لدراسة الحالة المحلية، المتمثلة فى العاصمة الإدارية الجديدة NAC في مصر، والتي تم اختيارها لأنها أكبر مدينة ذكية يتم إنشاؤها حاليًا في مصر. ونظرًا لأنها لا تزال لا تعمل بشكل كامل، فقد استندت البيانات التي تم جمعها إلى المخططات الحكومية والمقترحات والأوراق البحثية المنشورة حول المدينة والتي تم إصدارها خلال السنوات الخمس الماضية. بعد دمج الأساليب الافتراضية المقترحة نظريًا في خطط NAC وإعادة تطبيق إطار التقييم، تم تحسين النتائج بشكل كبير في جوانب مختلفة. أوضحت هذه الدراسة أن NAC لديها أساس افتراضي قوي لتصبح مدينة متصلة ذكية، ولكن كانت هناك بعض الفرص الضائعة لدمج حلول ذكية افتراضية ليتم تنفيذها على مستويات مختلفة مثل الثلاثة حلول المقترحة في هذه الورقة للوصول إلى هدفها.

الكلمات المفتاحية: المدن الذكية الافتراضية، المدن الذكية المختلطة، انترنت الأشياء، التوائم الرقمية، إطار العمل للتقييم الدائري لإجراءات المدينة.

1. INTRODUCTION

The spike in popularity of the metaverse notion, as well as terms such as 'virtual reality', 'smart' or 'intelligent cities,' all begs the question of what the fuss is all about. Despite these terms' ubiquity, many use them without quite understanding what they entail, due to the fast-paced visual world we are living in; to quote Taylor and Saarinen "our postmodern world can be considered radically decentred and thoroughly disseminated" (Taylor and Saarinen, 1996), especially through IoT, information technology and the rise of the increasingly intelligent cities and communities we inhabit.

This research paper aims to investigate the virtual nature of intelligent cities and to do so, some of these ubiquitous terms need to be defined, such as the virtual city, the digital city, and the intelligent city, as well as concepts and methods that pinpoint the virtuality of these intelligent cities, from the smart reusable nature of the sharing economy concept to the large-scale cloud-based intelligent approach of virtual power plants, to the time-saving fast-paced smart parking systems. These are the chosen virtual-intelligent approaches that were discussed further and incorporated into the local case study's blueprints.

Through this study, this research paper delved deeper into what types of virtual technologies could be implemented on a large scale in the city to create a more intelligent sustainable city while using the CCA framework to assess both the international case studies discussed as well as the proposed plans for the local case study, the NAC of Egypt. Since it is still a work in progress, this research paper reviewed the NAC's proposed plans and policies considered 'intelligent,' and provided recommendations that include and maximize the IoT- and ICT-based virtual technologies in such strategies to provide a more enhanced virtually embedded intelligent city framework to build upon.

2. METHODOLOGY

The research methodology sequence for this paper is divided into segments; (1) the literature review in which the study's theoretical background will be set, including the definition of main concepts such as the virtual and intelligent city, as well as the virtual aspects of intelligent cities the study focuses on; (2) the assessment framework that was used to analyse certain aspects in the international case studies and which aided in defining a proposal for the local case study; (3) the analysis of the local case study, the NAC, through the collection of a plethora of data regarding governmental plans related to it, either from governmental documents or publicly issued presentations, as well as published peer-reviewed journal papers focused on smart policies or sustainability plans.

As mentioned, the data collected in this study is based on governmental articles, proposed plans, and published papers written about the NAC in the past 5 years. The NAC is an upcoming urban project to be built in Egypt, also considered the largest in recent history. Given that authorities claim it is to be designed as an intelligent city, as well as the fact that it is still in the making, make it the most convenient city to study and analyze. To classify the relevant data, this study looked at different scales of the proposed virtual intelligent implementations with a "micro to macro" approach, to provide various implementations of different natures, from governmental, economic, as well as transportation- to infrastructure-based.

Then, the previously mentioned framework was applied to this gathered data, upon which the lessons learned from the international case studies were extracted and tailored to the local case study's plans. In the discussion section, certain recommendations from the takeaways of previous cases are provided, meant to be added to the NAC's plans to capitalize on, expedite, and maximize the efficiency of the virtuality of the NAC, and from there act as a base for other intelligent cities to learn from. This impact could later be studied further with the simulation within a Digital Twin of the NAC.

3. LIMITATIONS

Due to the nature of this study, the primary limitation was the qualitative nature of the data provided since the NAC is still not fully functioning and could be considered a work in

progress. Thus, this research paper's arguments are based on the information gathered from proposed ideas, plans and policies. Another issue with this approach is that most of the gatherings are considered secondary data, simply because of the lack of primary data available. This highlights another limitation, and that is the limited amount of official governmental documents describing in detail the proposed plans to achieve the smart aspect of the city, which is understandable because of the nature and scale of building an entirely new capital. However, when the city starts functioning fully, explorations of a similar nature would be much easier to conduct, as there would be tangible data to collect and policies set in place, allowing for a reassessment of the level of intelligence and sustainability of the NAC. Further limitations could be considered in the international case studies as well, as they could also be considered infantile given the concepts discussed are relatively new technologies on the city scale. Some of these projects either exist on a small scale or are too premature to define their level of success.

4. LITERATURE REVIEW

4.1. Understanding the Virtual City

Hearing the term *virtual city* could cause one to link it to alternate, non-realistic spaces, where the laws and rules of our current realm don't apply to this new space, leading one to believe that the option to push boundaries is more intriguing than in a physical city. However, that may not really be the case, despite the amount of misleading connotations in literature describing the virtual city as, for example, "fundamentally and profoundly unspatial" (Mitchell, 2010). In actuality, the *virtual city* can be considered a mirror that shows the hidden and intangible transactions, communications, services, and information flow that make up the 'reality' of the physical city we inhabit (Firmino, 2003). It might even be considered an alter ego to our existing cities, showcasing hidden layers, as well as the various conjunctions and overlaps of various flows, but according to Firmino, these parallel layers make it a parallel city (Firmino, 2003). However, the virtual city is not just considered a parallel urban city, as it bears just as much complexity – with variously interwoven layers – as its physical counterpart, and as such, it has actually become embedded within the tangible city. Thus, it should be considered yet another face of the city, which links and connects different flows of information. This then begs the question, how can the virtual sources and drivers of city intelligence – which assure a higher efficiency in addressing the dilemmas of contemporary urban agglomerations – be understood? First, one needs to understand how the virtual city works. It is built with building blocks, as is the case with the physical city, although in this case it is data and information that make up this intangible city. These bits and bytes of information are constantly building new intangible urbanism, and since knowledge is always in flux, so is the infrastructure of a virtual city (Mitchell, 2010), which makes it easy to build, reshape, connect, and respond to any problem. It also makes it quite resilient unless the cloud falls.

4.2. Virtuality of Intelligent Cities

An intelligent city is one that capitalizes on ICT and IoT to connect the different aspects of the city together, allowing for the most efficient services and readiness to solve any problems that may arise. It aims to improve transportation, accessibility, and social services, promote sustainability, and give its citizens a voice. The main goals of a smart city are to improve policy efficiency, reduce waste and inconvenience, improve social and economic quality, and maximize social inclusion. There are two major driving forces that sustained the paradigm-shift towards intelligent cities – the rapid rise of the knowledge and innovation creative economies – which sustain contemporary economic development worldwide. Now, with the even faster spread of the Internet and sprawl of cyberspace that intertwines the physicality of our world, they became major players in the rise of intelligent societies, thanks to the fourth industrial era (Konmēnos, 2012).

An *intelligent city* depends on both the physical (existing) city and its ICT-based virtual counterpart. Increasingly more scholars, as well as city governance workers have started to implement and utilize the virtual counterpart of their cities to migrate, mitigate and evolve their cities into more intelligent hybrids (Konmēnos, 2012). So, what makes an

intelligent city intelligent? Basically, it learns from the past by sustaining the knowledge economy in developed countries, which it applies to future scenarios by facilitating rapid urbanization in developing countries (URENIO, 2020). Achieving intelligence requires certain types of intellect, and that is where URENIO's *spatial intelligence* of cities idea comes in. This refers to the urban cognitive processes of gathering, digesting, and building upon the streams of information from the urban context. Through the digestion part, the city can process in real-time, and alert, forecast, and learn from its inhabitants and its machines. This collective intelligence distributes problem-solving to different key players, and thus reaches solutions faster – one of the most prominent features of an intelligent city. The emphasis on the spatial dimension denotes that urban space and agglomeration are preconditions of this form of intelligence (URENIO, 2020).

4.3. Assessment Frameworks

Cities are extremely complex systems with all their interwoven layers and players, and since components that make up urban systems vary widely in form and nature – from resource flow to food distribution – intervening and creating change in any one of these components will most probably impact others, creating ripples in the entire system and thus creating systemic change (ICLEI, 2021). Taking the sustainable city as an example, it has to consider its social, economic, environmental, and cultural integrity. If it evolved into an integrated city – a virtual-intelligent-efficient hybrid city – theoretically it would be possible to achieve a high level of urban sustainability. But, how can this level of sustainability on the urban scale be assessed? This is where the frameworks come into play, and specifically in this case a merger of two frameworks to analyse the chosen case study cities. These two frameworks are *the Circular Economy Key Elements Framework* (*CEKE*), and the *ICLEI (International Council for Local Environmental Initiatives) Framework*. Where the CEKE Framework focuses on decoupling the economy from material flows, regenerating ecosystems, and focusing on the rate of resource reproduction, the ICLEI Framework works towards low emission, nature-based, equitable, resilient, and circular development designed to create systemic change (ICLEI, 2021). However, by combining both, a new framework was achieved – the *CCA* framework, which this study has adopted into its analysis.

4.4. Circular City Actions Framework

This is a framework that was developed by ICLEI (Local Governments for Sustainability) as well as the MAVA Foundation, Circle Economy, Metabolic, and the Ellen MacArthur Foundation, which together refined their assessment and guidelines to create the CCA framework. They also paired it up with a policy toolbox and a governmental monitoring framework and divided it into five interconnected strategies that can be utilized to create more efficient circular city systems. These five strategies are:

1. **Rethink**

   This is where the foundation for circular activities is laid, which enables that shift to become a circular economy through redesigning the system. This could be done by eliminating linear incentives, setting goals and incentives for circularity practices, and supporting *closed-loop systems* as well as *cross-sectoral synergies* on the urban governance and commercial level, and enabling a sustainable lifestyle on the resident level.

2. **Regenerate**

   This core strategy relies heavily on harmonizing with nature by embracing infrastructure, production systems, as well as sourcing that allows natural ecosystems to thrive. This strategy is quite important as it aims to protect and restore our natural ecosystems by prioritizing renewable resources and promoting solutions inspired and supported by nature.

3. **Reduce**

   This strategy is based on doing more with less, and that is envisioned to be done through designing infrastructure, processes, and products that would minimize

material usage, water and energy consumption, and waste generation, from production to the end-user consumption phase. This would be applied by supporting local, low-impact circular economies, as well as circular and resource-efficient business innovations, plus designing infrastructure and a built environment that maximizes resource efficiency.

4. **Reuse**

The fourth main strategy aims to use longer and more often by extending and intensifying the use of existing resources, products, spaces, and infrastructure. This could be achieved using several means, such as second-hand markets or sharing and exchange platforms, which could be considered a take on the Sharing Economy. It can also support the reuse, repair, remanufacturing and maintenance of existing resources, products, spaces and infrastructure, as well as the design and regulation of streamlined processes for extended use of property and resources.

5. **Recover**

This is where they aim to make waste a matter of history, through maximizing the recovery of resources at the end of the use phase and reintroducing them once more into production processes. This could be executed through a three-phase process: (1) design and regulate for separation and recovery of the suitable waste; (2) the waste collection and sorting process itself which would help facilitate recovery; (3) and finally, processing waste and ensuring its re-entry into the industry at its highest value.

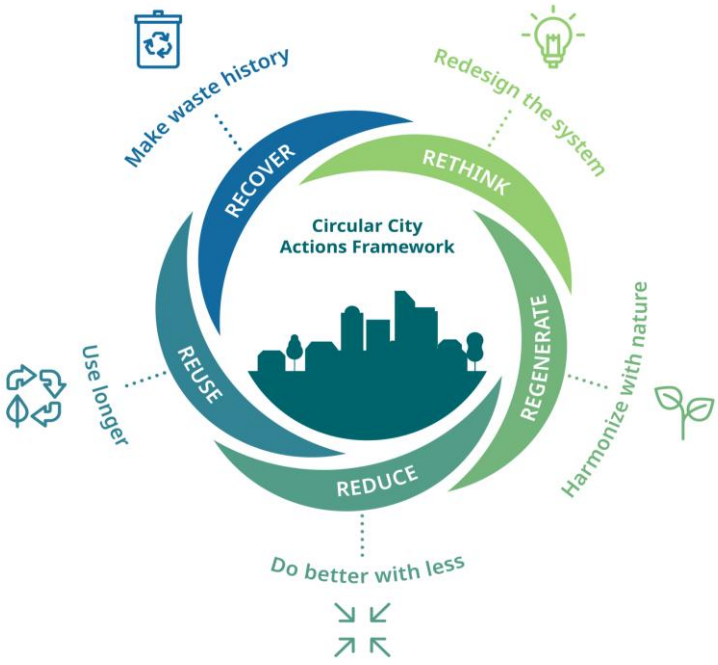

Fig.1: Circular City Actions Framework (ICLEI, 2021)

4.5. Virtual Methods That Make Cities More Intelligent

Now, how do these types of Intelligence modules help our cities? If they are applied in the virtual cloud-based counterpart of the city, it could be upgraded into a more efficient intelligent city. However, there are countless ways of utilizing technology and cloud-based intel to maximize cities' efficiency, among them being simple methods in various sectors and on different scales.

4.5.1. Micro Scale Concept Study: Sharing Economy

The sharing economy is an economic model defined as peer-to-peer-based, but what makes this type of economy quite vibrant and fast-paced is the fact that it is short-term and utilizes idle assets and services provided by or to facilitate collaboration (Investopedia, 2021). The sharing economy often involves some type

of online platform that connects buyers and sellers. This again links to the virtuality of the city, where such an online platform that aids such transactions can be considered the virtual counterpart of a marketplace or mall. If somehow governed moderately, and even supported by the general urban governance and its citizens, such virtual spaces could be made safer spaces for the provision of urban services and thus would thrive even more, and thus feed into the urban economic ecosystem. The exceptionality of sharing economies lies in their allowance of individuals and groups to monetize on barely used products and assets such as cars and property, as well as the fact that they provide a vast array of assets to choose from (Investopedia, 2021).

Assessment: As a concept, it implements the **reuse** strategy to almost its maximum potential since it connects different people through a shared interest. Also, in a transaction, both parties **recover** by utilizing existing assets without having to supply new products, while an increasing number of users get access to this virtual marketplace and all parties benefit from it. If the issue of governance is resolved, this strategy may reach its utmost potential.

4.5.2. Semi-macro Scale Concept Study: Smart Parking System

This IoT digitally based transportation system is loosely based on the previously discussed concept *sharing economy*, but is operated by deploying a convenient amount of sensors along the road networks which record, digest, process, and monitor data to create real-time traffic occupancy data for the area a user is heading to (Burbano, 2021). Implementing smart technology to facilitate this task will solve this problem, enhancing operational efficiency, simplifying the flow of urban traffic, and offering drivers a more enjoyable and time-saving experience. It also reduces the harmful effects of congestion as less cruising equates to fewer greenhouse gas emissions (Burbano, 2021).

Assessment: As with the previous concept, *smart parking systems* also capitalize on the notion of sharing economy, however, the strategy utilized here is to **reduce** – namely, time and energy consumption, as the user knows the exact location of a parking spot in advance.

4.5.3. Macro Scale Concept Study: Virtual Power Plants (VPP) and Case Study: VPP in South Australia

South Australia's VPP basically connects the source of energies and materials directly with consumers (i.e., citizens), and manages them remotely. Achieving the renewable energy integration target will require extensive consumer and private sector engagement in the investment and operation of renewable-based energy systems, and VPPs are an efficient way of accomplishing that (Behi, 2020). Optimization algorithms and resource flow management can be achieved through the cloud and satellite technologies to save time, energy, and land. In Adelaide, South Australia – the pioneering VPP-based city – batteries and VPPs are utilized to manage infrastructure and power flow needs.

Assessment: This complex infrastructure system incorporates **reduces**, **regenerates**, and primarily **rethinks** strategies into the traditional system**.**

5. DATA COLLECTION

The local case study is the NAC, which is the newest and largest city being built in Egypt currently is 45 km East from Cairo, with a total area spanning 170,000 feddans; 650 km of which are roads (MoHUUC, 2018). The NAC is divided into 3 phases; the first of which is 40,000 feddans, consisting of 20 residential districts, can house up to 6.5 million residents, as well as an international airport, the governmental district, commercial areas, public gardens, and large street networks for different modes of transportation (MoHUUC, 2018).

According to the Egyptian government's proposed plans, the NAC is meant to become a connected city that is reliable, high-speed, and efficient, as well as a *digital* city, that is both fully automated and revolves around customer-centric services, ensuring more efficient operability (ACUD, 2017). The proposed plan aims for a *connected* city built upon a unified information- and data-sharing base, where all aspects of the city communicate efficiently, from the stakeholders to the machines and buildings (ACUD, 2017).

5.1. Micro Scale: Smart City Furniture in the NAC

One of the interesting strategies considered both tangible and virtual is smart city furniture. Several ideas have been posited regarding intelligent connected urban furniture that documents user needs and actions, responds to the environment, and also coordinates with other urban components. This feature would correspond to and maintain the intelligent traffic system (ACUD, 2021); e.g., the proposed bus stations interworking with traffic lights, which alert users when a specific bus is approaching based on information received from traffic lights (ACUD, 2021). This type of urban furniture responds to a smart connected mobility scheme, but what about an environmental aspect? There also exist proposals and implementations such as solar-powered streetlamps, which also converse virtually with other city elements, as they would be connected to hi-tech sensors which monitor air quality and both vehicular and pedestrian traffic (Hassanein, 2017).

Assessment: Smart Furniture applies both the **reduce** and **reuse** strategies, as they have several functions and serves several purposes, as opposed to the traditional non-responsive ones. Their use of renewable energy means they are environmentally responsible, and the amount of power needed to operate them on a city scale is relatively low. These smart elements add a layer of connectivity on the street scale.

5.2. Semi-Macro Scale: Digitizing Nationwide Public Services

There are several articles published through Egypt's State Information Service website that are in favor of creating digital systems for data gathering and sharing, where they would transform many of their services into digital cloud-based systems that integrate and unify all types of information regarding management and operation in the city (SIS, 2018). Considered one of the major axes to tackle to achieve the UN's SDGs for 2030, ICT and IoT technologies would create smarter, more intelligent cities through a comprehensive virtual system that makes information readily available to the different sectors of the state (SIS, 2018). This system would entail digitizing all types of public services, from notarization to electricity, agriculture, and much more (SIS, 2020).

This, in a sense, could lead to the redundancy of physical public service for buildings, as the service will rely on the cloud and different sectors' integrated databases (SIS, 2020). The promised nationwide application of this system by 2030 would be truly world-changing.

Assessment: Applying the CCA framework shows this nationwide approach incorporates both a **rethinking** and a **reducing** strategy; the entire idea of public services was re-imagined and optimized through the creation of its virtual digital counterpart. This can be considered a cross-sectoral synergy that aids the governance of the city, as well as reduces the need for citizens' multiple commutes to different governmental buildings for simple procedures, thereby reducing emissions and energy consumption. In addition, the amount of labor, buildings, and infrastructure would be greatly decreased. Overall, this system would be less costly, allow for more efficiency in city management and operation, and from the user end, greatly reduce the time and effort usually required to obtain documents and services.

5.3. Macro Scale: Smart Infrastructure in the NAC

Infrastructure in the NAC is proposed to be designed in a way that conserves water efficiently, as well as recycles organic waste more effectively. They also incorporated Honeywell City Suite technologies in their infrastructure, especially within "New Capital Egypt, City Operations Center" and "New Capital Egypt, Integrated Command & Control Cente" (ACUD, 2017) The proposal aims for an interconnected city powered by high-speed

internet, open data, and GSM (4G+) technologies, all of which would be primarily powered by solar power given it is a desert city (Hassanein, 2017).

Assessment: This entire infrastructure system that aims to incorporate and handle smart techniques applies several strategies, specifically the **rethink**, **regenerate** and **reduce** strategies**.**

6. DISCUSSION

It must be noted that these virtual intelligent methods will not alter the conceptual design of the NAC due to its virtual nature. Juxtaposing these virtual methods onto the NAC plans would result in the intelligent interconnected city that the NAC aims to be, and incorporates the virtual intelligent solutions discussed earlier is shown and discussed further below.

Table 1: CCA Framework Application.

	Scale	Approach	Circular City Actions Framework				
			Rethink	Regenerate	Reduce	Reuse	Recover
Virtual Methods	Micro	*Sharing Economy*				X	X
	Semi-Macro	*Smart Parking System*			X		
	Macro	*Virtual Power Plants (VPP)*	X	X	X		
NAC Plans	Micro	*Smart City Furniture*			X	X	
	Semi-Macro	*Digitizing Nationwide Public Services*	X		X		
	Macro	*Smart Infrastructure*	X	X	X		
Applying Virtual Methods to the NAC Plans	Micro	*Smart City Furniture + Sharing Economy*			X	X	X
	Semi-Macro	*Digitizing Nationwide Public Services + Smart Parking System*	X		X		
	Macro	*Smart Infrastructure + VPP*	X	X	X	X	X

6.1. Micro Scale: Smart City Furniture in the NAC + Sharing Economy

Since the Smart Furniture System regulates traffic and monitors the city's general mobility, and the major issue with sharing economy is lack of monitoring and governance, thus making it relatively unsafe for public use. Juxtaposing these virtual methods onto the NAC plans would result in the inherently intelligent interconnected city that the NAC aims to be and identifies and proposes virtual intelligent solutions in its design to reach its goal, therefore together this issue is resolved. By adding a Sharing Economy space within the Smart City Furniture embedded throughout the city, where people could present their products in the public virtual space with a lot of constant traffic as they wait for their mode of transportation. This online marketplace of underutilized resources can be **reused** safely and create a new type of economy that is less money-based and more asset-based, and this would then **reduce** the need for new products and services since they will be **recovered** through this virtual marketplace and showcase.

6.2. Semi-Macro Scale: Incorporating Smart Parking Systems Through the Digitized Nationwide Public Services

If this service is provided through the government portals where they can be monitored for street violations and would greatly save time and reduce energy and emissions wasted while finding a parking spot. Since, it will be connected to the NAC's Street sensors, which link to the governmentally monitored and linked to a mobile app, this modification would be adding **rethink** to the **reduce** strategy.

6.3. Macro Scale: Adding VPP to the Smart Infrastructure in the NAC

Although the proposed infrastructure seems to have certain environmental goals, this could be taken a step further through the implementation of VPPs, eliminating the structural and power costs associated with building an entirely new physical power plant.

Instead, the energy resource flow would be redirected from the source to the grid and operated remotely, making the process more efficient and transparent; the government would easily monitor and govern where the energy comes from, who uses it, when, and how much. Therefore, adhering to the **reuse** strategy. Set-up should also not be much of an issue, as the digital infrastructure it requires should already in place given the NAC is designed to be an interconnected city equipped with high-speed internet, open data, and GSM (4G+) technologies. Another important factor of this proposal is that citizens would be able to reuse any excess energy by storing it in batteries, which in a sense can also be considered a **recover** strategy. With the VPP added to the existing proposal of the infrastructure, this covers all five strategies of the CCA framework.

7. CONCLUSION

From what was gathered, analysed, and discussed, a conclusion can be reached – the NAC has a strong base for being an intelligent city, however, it needs to implement more IoT- and cloud-based virtual strategies to reach peak intelligence. All these approaches if incorporated would add at least one more of the CCA framework strategies to the existing ones. The smart furniture case, for example, is more than halfway to the proposal suggested in this research paper, as these smart connected elements are installed all over the new city and some are even working at the moment. The addition of a connection to citizens' phones and the Smart Parking feature would allow the city to reach a whole new level of efficiency. Adding the Sharing Economy platform to the Digitizing Egypt movement would not just lead to reuse and recovery of idle resources taking up precious space, it would also generate income for both citizens selling these resources as well as the government, which would monitor and keep this entire digital-based interaction safe, rendering it a favourable situation for all stakeholders. Incorporation of VPPs into the proposed smart infrastructural system would mean that the five strategies would be in one way, or another achieved.

These three propositions are just the gateway to many more virtual strategies that could be weaved into this new city, with the addition of intelligent and smart city-based policies that truly cater to these new technologies and would protect all stakeholders from any fraudulent activities that might arise from incorporating such new technologies onto the city scale, would definitely be a breakthrough.

Each new day sees the rise of new virtual and cloud-based technologies that could be incorporated into our cities, especially with the rise of real estate in the metaverse. If this research were to be conducted again in five years' time, it would contain more quantitative data, where the data collected would be gathered from the city itself, and these never-before-implemented strategies and policies could be analysed in the realized city.

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