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Mega Projects Evaluation Criteria: Case Studies from Kuwait Industrial Project

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Abstract— Mega Urban Regeneration Projects (MURPs) have become key features of regeneration in many cities. Like many large projects, MURPs, because of their complexity and scale, often face the difficulties of being over-budget or late. This research aims to develop and validate a new framework to evaluate mega urban regeneration projects. Four objectives were formulated to address those problems. Firstly, to explore the nexus between MURP, urban transformation, and globalization. Secondly, to identify the characteristics of sustainable mega urban regeneration projects. Thirdly, to investigate existing sustainable urban regeneration frameworks. Fourthly, develop a framework to evaluate Mega Urban Regeneration Projects and, finally, validate the framework.

Keywords: *Mega Projects, Industrial, Policy, Project*

1. INTRODUCTION

In the coming decades, cities confront substantial growth with internal and external challenges [1]. Disastrous incidents like war, tsunamis, or volcanic eruptions are dramatic examples of external threats. One response is to build a new garden or other cities. Alongside external distress, cities change endogenously. Poor management and diminished infrastructure can leave an unstructured sprawl and pollution—unstructured urbanization results in poor health, air pollution, traffic congestion, and crime. The failure to tackle spatial and market externals are not sustainable.

Additionally, today's rapid urbanization of the 21st century resulted in the regeneration and expansion of cities. The UN estimates that by 2030, the world will have 41 megacities (cities with 10 million inhabitants or more), and above half of the world's population will be urbanized. It is worth noting that this population rush has been one of the responses to the opportunities that cities offer - such as the opportunities created by the wealth and economic developments. This rush has created the phenomenon of 'megacities' in the cities, which has affected the cities more than ten times the size of the past's largest cities. It has brought problems and challenges alongside the potential they offer. The advocates of new urban policy seek to address these issues via Mega Urban Regeneration Project s (MURPs) and similar emblematic developments [2].

Whist many cities have always been trading hubs, links between urban centers and the global financial system have been strengthened by worldwide trade. They are rapidly assuming a key position in economic changes. The extension of the business, capital flow, and a wave of new technologies are among the critical components in the new global system's evolution. Indeed, economic development and improvement among nations worldwide are highly dependent on the globalist transformation taking place within their urban communities. Olds (1995) considers MURPs as part of the broader trend towards globalization.

Notably, globalization itself was driven by Foreign Direct Investment (FDI) and Multi-National Corporations (MNCs) as they sought to treat the whole world as a single complex marketplace. MURPs became a vital part of the changes this process brought about, as urban policy by national and local governments sought to use such megaprojects as a tool for regenerating their cities. Sometimes known as Flagship Projects, MURPs played a part

in urban transformation whose other strands included urban branding, city imaging, and city marketing [3].

MURPs require a long development cycle and are prone to risks such as cost over-run due to their complex nature and scale. The associated costs of such projects make them particularly risky - hence they can be challenging to finance. As Flyvbjerg (2003) and Altshuler and Luberoff (2003) indicate, megaprojects are often notorious for failing to keep within budget and time schedules. Almost nine out of ten Megaprojects face cost escalations with an increase of 28% on average [4]. The risks associated with implementing such projects also include the potential bankruptcy of different partners, especially private firms, political instability in less stable countries, and financial crisis at global and national levels (Bruijn & Leijten, 2007). Metropolitan cities such as Kuwait have attracted many speculative and more-informed inward investments to finance their intensification. Sustainable MURPs can 'redress the regional economic imbalance,' and 'their remit extends beyond technical considerations of time, cost and delivery' [5]. Nevertheless, the very complexity of MURPs means that they often run overtime or over budget. Almost by definition, they have concentrated spatially on three (3) a particular urban district, which often tends to be in a capital city.

2. URBAN REGENERATION POLICY IN KUWAIT

The origins of urban policy in Kuwait date back to the 1930s when the government began to take direct action to deal with the problems generated by mass unemployment. In Kuwait, the urban and regional policy was developed as a series of trials proposed by governments following their ideological approach on the procedure, which a subsequent government might then reverse. Early policy (1940s-1970s) aimed to create geographically mobile investment in areas with an employment deficit. From the late 1970s, there was a particular focus on the inner cities, which were beset by social and economic problems. When Thatcher was in office, the market and property investors led the urban policy, which led to a focus on relatively small geographic areas with initiatives to support disadvantaged residents [6].

The urban policy of the 1990s and 2000s has focussed more closely on the demands of disadvantaged people, intending to create holistic economic and social regeneration mainly at the level of the neighborhood.' Alongside this, the government has tried to reduce regional inequality [6]. Atkinson and Moon (1994) outline the changes to Kuwait cities brought about by Margaret Thatcher's strategy of shifting power away from the state and the private sector. When New Labour came to power in 1997, Tony Blair's government set about addressing some of the problems of social inequality that Labour felt were caused by Thatcherism. There was a particular emphasis on "narrowing the gap" – reducing disparities between regions and different districts of specific cities. They had a specific focus on areas, and especially on "city regions" –

Roberts (2000) records how, since 1945, social reconstruction's responsibility has tended to change hands in line with the general social and political transformations that were taking place in broader society towards the current model of public-private partnership[7]. He also notes that the post-war reconstruction projects were the UK's earliest attempts at urban regeneration. There is a possibility that these new paths to economic development, based on considerations for growth and market flexibility, will in fact worsen inequality. Where incentives are provided to investors, there is a risk that this will create a scenario of winners and losers.

2.1 Mega Urban Regeneration Projects

During the last decade, the number of Megaprojects in Kuwait, European and American cities has risen dramatically. Throughout the 1990s, major cities have responded to the pressures of the global economy by initiating MURPs that vary in terms of their social outcomes and planning processes. This is based on the level of commitment of each city and their concern for social equity ([8]. In 2016, almost 55% of the world's population lived in towns or cities, and this is expected to rise to 60% by 2030, by which point around 33% of people are expected to live in cities with at least half a million inhabitants. Recognizing and understanding these trends is essential for ensuring sustainable regeneration [9].

While urbanization endorses economic and social development, at the same time, this progress has its consequences in cities by produce housing shortages and also environmental problems such as biodiversity declines, resource deficiencies and air pollution [10]. Change in land use has been proved to leave side effects on the environment, reduce natural resources, and affect people's living conditions. Rezgui (2010) noted that the 21st century had faced significant global ecological challenges by putting the natural and built environment at prospective risks. This includes global climate change, urban sprawl, depletion of natural resources, and increased human conflict.

Old (1995) concludes the increasing importance (and indeed primacy) of many cities in economic and cultural terms, showing that the financial Restructuring brought about by the deindustrialization of the late twentieth century had brought about moderate (and in some countries rapid) economic growth alongside technological change. All of this has contributed to a rise in demand for MURPs.

2.1.1. Mega-Urban Regeneration Projects Evaluation

The model of sustainability can be differently perceived depending on the observer's viewpoint; for example, depending on whether their disciplines have a focus on social issues, technology, energy or policy.

A city must have high interaction with its adjacent ecosystem; therefore, to achieve a sustainable urban city, it is imperative to burden on ecosystems at the same time as enhancing the quality of life (Alberti, 1996). Sustainability indicators are considered as a proven method for the establishment of sustainable urban development. These sustainability indicators offer a handy and flexible tool for evaluating sustainable cities and integrated urban development in line with Europe 2020 strategies [11]. BREEAM, LEED for Neighborhood Development, EU Sustainable Development Indicators, Green Star, and New Urban District are standard national rating systems applied in Kuwait, which will be briefly introduced.

2.1.2. Urban Regeneration in the USA

Redevelopment has been popular throughout the USA since the late 1970s and is seen as a vehicle to facilitate real estate investment in targeted areas (Reuschke, 2001). World War II had a significant impact on American cities' social and economic patterns, substantially affecting urban development. In the 1940s, many cities changed because of deindustrialization and an extensive suburbanization move began in American cities. This resulted in a decrease in the population of city centers. Middle-class whites migrated to suburban towns surrounding central cities. State freeway programs also encouraged a migration towards the suburbs, which in turn transformed the character of the inner cities (Reuschke, 2001).

The challenges mentioned have resulted in "new directions in urban management," which form the basis of public-private partnership activities. Koebel (1989) believes that the public sector must build a relationship with private developers, investors, and speculators, to generate capital and political commitment for major urban development projects.

Originally, urban renewal was considered a housing program but eventually became one of the most fundamental ways of organizing public-private co-operation in the creation of commercial and/or industrial projects in American cities.For example, in California, local governments were obliged to seek new ways of funding urban development. Consequently, many cities began to raise additional revenue by becoming active partners with private real estate developers. The partnership model was created initially by the Carter administration which announced a 'new urban policy' in 1978, followed by Reagan'sNew Federalism' which was characterized by substantial federal cut-backs in urban programs.

3. MODELS OF URBAN REGENERATION IN KUWAIT

Since the late 1970s, urban policy has become increasingly focused on regeneration. Recognizing that cities are complex and dynamic systems, planning policy aimed to encourage cities themselves to become agents of their own re-transformation. Dalla Longa (2011) outlines eight different transforming cities: Urban Renewal, Urban Redevelopment, Urban Regeneration, Urban Recovery, Urban Revitalization, Urban Framework, Urban Gentrification, and Urban Restructuring. Below we consider each in turn. Urban Renewal refers to rebuilding Kuwait's cities following the Second World War (Smith, 2002). Urban Redevelopment refers to creating a new urban elite with its decision-making network and new business communities' proliferation. It is also a term used to describe the process leading to the more recent Public-Private-Partnerships (PPP) phenomenon.

Urban Regeneration was a term originating from the post-war city, applied to projects aiming to address both criminality and unemployment (Smith 2007). Avery notes that the term was used again in the UK in the 1980s and 1990s to describe the process that involved the establishment of ad hoc agencies to intervene in city life in terms of culture, economy, the environment and even politics. Robert and Sykes (2000) suggest that Urban Regeneration was often marked by divided or even contradictory objectives, such as the environment's competing needs and the economy. The term is also used for those policies that attempt to return derelict land and buildings to favorable use.

Urban Recovery refers to an exclusive physical aspect of the built property and has a direct consequence on the components of the urban structure, dealing with maintenance and conversion. According to Smith (2007), the term Regeneration was used to refer to policies designed to support the full legitimization of "gentrification." Tallon (2010), believed Gentrification is a diverse and all-around process that involves physical, economic, social and cultural transformations.

In Kuwait, Gentrification tended to be associated with the rehabilitation of older inner-city housing areas, resulting in a class transformation of the area from working-class to middle-class, besides a change in tenancy types from private renting to owner-occupation (Hamnett, 2003). Urban Restructuring explained the change in the 1980s, upon the establishment of modern globalization and Restructuring of production sectors that embrace a strong influence on urban areas.

This thesis is particularly interested in Urban Regeneration which attempts to reverse the urban decline by creating a physical structure that is intended to have a significant impact on the local economy. Thus, the term regeneration takes on a more social connotation, containing an economic element in which the physical component is less important. Having explained the different transforming cities' models, different types of urban regeneration models will be demonstrated below. There are four different types of urban regeneration models in the UK; retail-led, housing-led, designed and culture-led regeneration.

3.1 Retail-led Regeneration

Since the 1980s, retail-led regeneration has been a leading urban regeneration model and is acknowledged as a crucial way of revitalizing urban areas by providing jobs, stimulating economic development, creating attractive places and as an important place-making tool in wider urban regeneration (Kima & Jang, 2017).

In Kuwait, the government of the 1980s tried to attract investments by using retail centers as a way for regenerating deprived areas; thus, the Enterprise Zones (EZs) been introduced. This EZ policy was to support business activities by allowing tax relaxation or accelerating the application of statutory or administrative controls, leading to the development of several retail centers on brownfield land such as the Swansea enterprise zone, Kuwait Shopping Centre.

In the final years of the twentieth century, urban planning was increasingly concerned with repopulating and revitalizing inner-city areas (Tallon, 2010). It had been noted that there had been a population decline in city centers as a result of upwardly mobile citizens migrating out towards the suburbs, a phenomenon recognized by the Kuwait government as early as the late 1960s. The government strove to encourage a "back-to-center" approach to see shops and services returning to the inner city and encouraging people to take up residence there. By the 1990s, planning policy was actively designed to shift economic activity back to the city center and away from the out-of-town shopping complexes that had marked the previous era. Policies to promote this included 'living over the shop' (LOTS) strategies, which New Labour aimed to supplement with their proclaimed "urban renaissance, which would make inner cities more attractive places to live and work. Sometimes labelled Gentrification, the policy was justified on the grounds that it would encourage the wider regeneration of the city.

High-density urban living was first introduced by Le Corbusier (1929), who had first explored what he called high-density urban living; this would reduce travel distances and encourage an energy-efficient urban development. It was an idea revisited by Roger's concept of the sustainable city (1997), in which "compact and polycentric" communities would help create a greener and more sustainable cities.

4. RESULTS AND DISCUSSION

Fig. 1 presents a bar chart by which international infrastructure risk factors are illustrated on the x-axis and their corresponding percentage of authors' agreement.

In relation to the paper context, Egyptian-specific infrastructure risk categories have further been highlighted in Table 1. The table presents four recognized risk categories which can impact Kuwaitian IP delivery. Data includes reviewed paper publishers, their corresponding categorized groups, and the percentage of authors' agreement. Fig. 2 presents the infrastructure risk categories on the x-axis and the corresponding % of agreed authors on the y-axis.

The RBS shall help the risk management team understand and, therefore, identify and assess the risk. Risk categories provide a structure that ensures the comprehensive process of systematically identifying risks to a

consistent level of detail and contributes to the effectiveness and quality of risk process identification. Table 2 presents the review for identified infrastructure execution risks and their corresponding number of agreed authors conducted from infrastructure execution risks in international and Egyptian literature. Fig. 3, shows the percentage of agreed authors and infrastructure risks in international studies, Fig.4 illustrating a bar chart regarding the percentage of agreement among authors on and infrastructure risks in Egyptian researches.

Fig. 1. Percentage of Agreed Authors and Infrastructure Risks in International Studies.

Table 1:Infrastructure recognized risks categories in Kuwait

Author	Risk Category	% Agreed
Ghada (2016), El Kholy (2015)	External factors	34
Hamdi (2002), Ibrahim et al (2014), El Kholy (2015), Emad (2014), Ahmed (2014)	Financial risks	83
Ibrahim et al (2014), El Kholy (2015), Ghada (2016), Ahmed (2014)	Projects Management	67
El Kholy (2015), Ghada (2016), Emad (2014)	Technical related	50

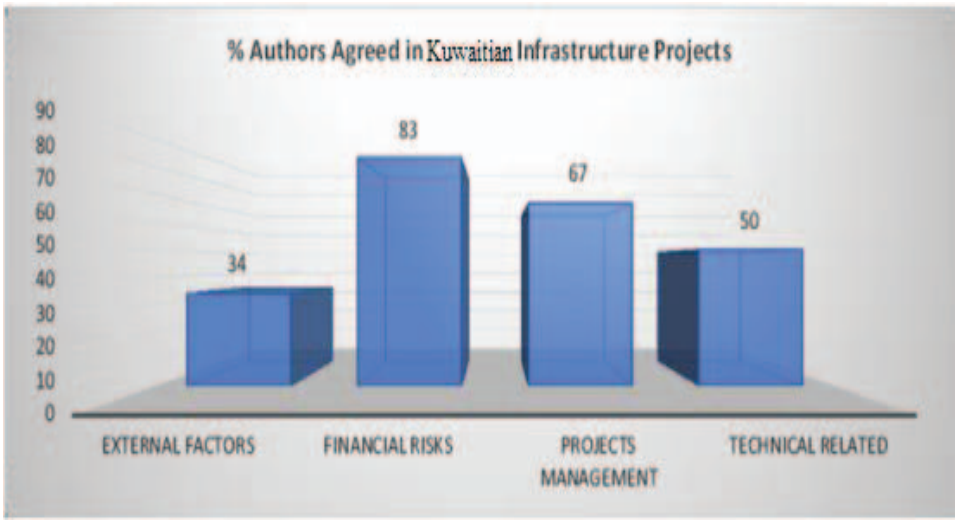

Fig. 2. Percentage of Agreed Authors and Infrastructure Risks Categories in Kuwaitian Researches.

Table 2: Identified international and authors infrastructure construction risks

Author	Risk Category	% Agreed
Ghada (2016), El Kholy (2015)	External factors	34
Hamdi (2002), Ibrahim et al (2014), El Kholy (2015), Emad (2014), Ahmed (2014)	Financial risks	83
Ibrahim et al (2014), El Kholy (2015), Ghada (2016), Ahmed (2014)	Projects Management	67
El Kholy (2015), Ghada (2016), Emad (2014)	Technical related	50

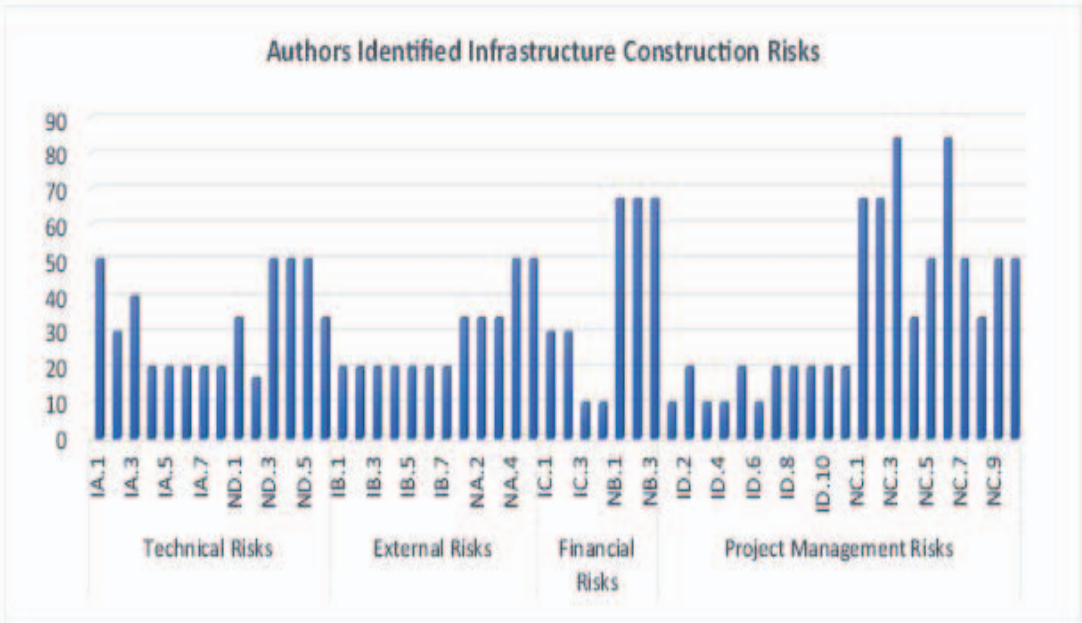

Fig. 3. Authors Identified Infrastructure Construction Risks

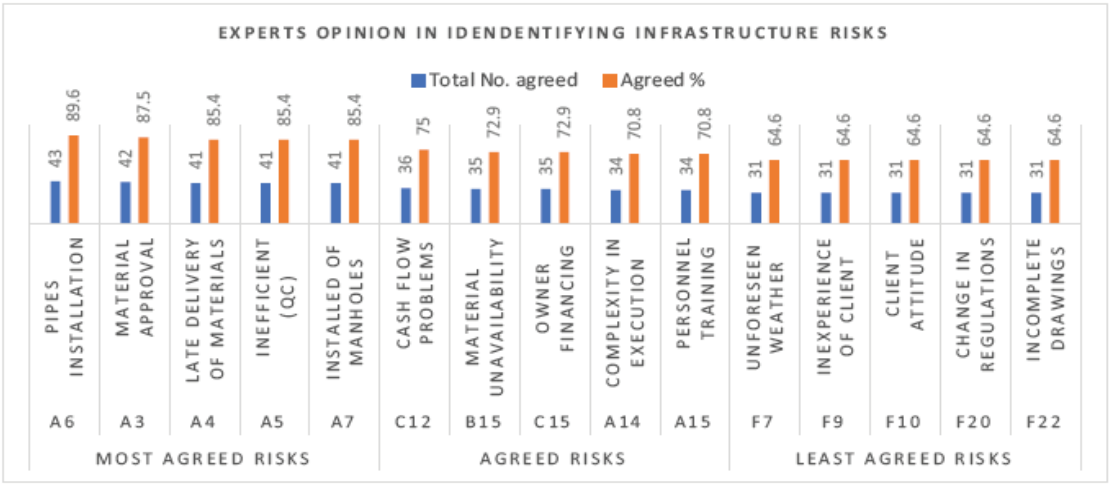

Fig. 4. Identified Infrastructure Risks based on Experts Opinions

5. CONCLUSION

This paper presents the risk identification process as the first phase of risk management processes, where this process is considered an iterative one, where new risks may arise during the project progress, through its life cycle. The frequency of iteration and who participates varies from one case to another. This paper's risk identification process alternatively leads to risk analysis processes, where risk factors are analyzed qualitatively. Infrastructure investment involves complex risk analysis, risk allocation and risk mitigation, given the highly idiosyncratic and illiquid nature. It is important to examine and identify project-specific potential hazards which can cause cost overrun and delay of infrastructure projects in Kuwait. It is said that 16.6% of projects always face cost overrun, 37% often suffer from cost increase, and 98% of Kuwaitian contractors have been delayed in delivering their project on time planned. This may be done by reducing them to a detailed level, allowing the evaluator to understand the significance of any risk and identify its origins and causes.

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Development of Agile Project Management Framework in Oil and Gas Companies in Kuwait

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Abstract— The Petroleum industry requires construction and renovation of 'upstream' and 'downstream' facilities. Kuwait Oil Company is dealing with the exploration and manufacturing of crude oil & natural gas. EPC projects perform an essential role in the technology of new physical amenities to keep or decorate production. Project administration has developed incredibly over time due to several strategies to deal with building activities. Schedule and Budget are the two most important concerns required to be optimised all through execution. Therefore, a very excellent & efficient challenge management system is wished and has to be framed to deal with the fundamental capital construction projects. In effect, help the organisation makes have an impact on the country's economy.

Keywords: *Information Systems Project management, Critical Success Factors*

1. INTRODUCTION

With the oil recovering fee, many oil and gas (O&G) corporations international are launching new capital tasks to pursue growth. But due to the fact many tasks now are competing with renewables, success will require retaining expenses down and keeping timetables better than in the past. According to a 2017 McKinsey Global Institute report, the extend in productiveness in the O&G development sector lags in the back of the manufacturing and retail sectors.

O&G businesses can use administration practices and digital technologies deployed through different industries to increase capital-project productivity. Project Production Management (PPM), digitising processes, advanced analytics, and agile ways of working can all yield huge improvements. But in reality, copying such practices won't be enough because O&G tasks are unusual in some essential respects. In particular, no O&G mission is equal to the one that preceded it, and lead times are incredibly long. Moreover, group personnel frequently change with the project. Consequently, each new venture brings a new set of challenges and a new mastering curve, for that reason limiting the potential for boosting performance.

Suppose O&G groups can adapt these practices to meet the needs of their special environment. In that case, widespread enhancement is possible: by way of our estimate, and We can decrease improvement time by myself with the conceivable to supply 15 to 30 percent in price savings. As extraordinary installations and applied sciences grow to be extra commoditised, O&G players that don't revamp their approach to capital projects now may additionally be pressured into ever greater technically specialised—and regularly costlier—projects. The possible advantages could be well worth billions.

The Agile Manifesto was first defined in 2001 by a group of independent software developers [1, 2]. As per Schneider [3], the Agile mindset is all about building the right solution today and acknowledging that this might not be the right solution tomorrow. Compared to the waterfall approach, it is rapid and iterative. Agile focuses on

quality while applying continuous improvement principles. The literature review identified that the vast majority of sighted artefacts recommended an agile project management approach for big data analytics projects. On the contrary, only one interview confirmed this and another interview stated that a hybrid approach of waterfall and agile was applied.

Agile Project Management is a paradigm shift from the everyday plan-then-execute-project paradigm that embraces the fundamentals of the everyday four-stage (initiate, plan, execute, close-out) mission life-cycle phases to a new five-phase (envision, speculate, explore, adapt, close) undertaking lifestyles cycle, as described via Highsmith [4]. Traditional PMMs aim to forestall alternate by using the usage of considerably planning and documenting as lots as viable earlier than the gadget is developed, at the same time as APM accepts that alternate is inevitable and that it is now no longer to be averted then once more managed [5]. "Agile Project Management lets software application software program mission managers and personnel alike adapt to altering circumstances, as an alternative than to decorate inflexible formal controls as in common linear enhancement methods" [6].

2. AGILE PROJECT MANAGEMENT VALUES AND PRINCIPLES

The three core APM values [7] summarise the Agile Software Development Manifesto and Declaration of Interdependence headquartered via the use of using the Agile Project Leadership Network (Highsmith, 2010:14)[8]. The Declaration of Interdependence (Highsmith, 2010:14) will be first, after which the three core APM values will be provided:

- We make a large return on funding via making the non-stop flow of fees our focus.
- We supply dependable penalties by way of fascinating customers in regular interactions and shared ownership.
- We matter on uncertainty and control for it with the aid of capacity of iterations, anticipation, and adaption.
- We unleash creativity and innovation with the aid of recognising that humans are the closing supply of value and developing a surrounding the location they can make a difference.
- We bring up average overall performance with the aid of group accountability for penalties and shared accountability for crew effectiveness.
- We enhance effectiveness and reliability by way of situationally distinct strategies, processes, and practices."

The three core APM values (Highsmith, 2010:14–17) embody the following:

i. Delivering cost above assembly constraints: This value presents "a focal point for rethinking how we measure overall performance on projects" (Highsmith, 2010:27). Traditional mission managers core of interest on handing over in accordance to the time, charge and gorgeous requirement constraints as defined in the assignment scope, at the same time as agile assignment managers middle of interest on turning in rate and "constantly asking questions about whether or no longer or no longer special renditions of scope are nicely well worth the value they deliver" (Highsmith, 2010:27).

ii. Leading the crew above managing tasks: "Agile leaders lead teams, non-agile ones manipulate tasks" (Highsmith, 2010:47). The fundamental focal factor of APM is to construct self-organising firms and to manipulate them with a "lead-by-serving mentality". There are four (4) predominant troubles related to growing teams:

iii. organising self-organising venture teams;

iv. leadership;

v. collaborative teamwork (including decision-making); and

vi. client collaboration.

vii. Adapting to trade above conforming to plans: Traditional project managers see the "plan as the goal" and middle of interest on "following the sketch with minimal changes", even as agile assignment managers see "client price as the goal" and middle of hobby on "adapting effectually to inevitable changes"

(Highsmith, 2010:63). The project layout turns into the capacity to reap positive wishes now, not the purpose itself, when super and consumer fees are the most critical objectives[8]. Although the constraints described in undertaking plans are very important, project plans are no longer sacred; "they are supposed to be flexible; they are supposed to be guides" that do now no longer restrain the crew (Highsmith, 2010:63). Agile Project Management requirements derived from the adaptive precept statements are summarised as (Highsmith, 2010:64):

viii. Accept alternate (uncertainty) and reply as a choice rather than learn about historical college plans.

ix. Adapt strategies and practices as necessary.

2.1 Agile business enterprise framework

Agile computer improvement methodologies have to go well with and modify to notable organisational constructions that consist of precise levels. The agile business organisation framework breaks an organisational shape down into attainable administration tiers that would cater to the acceptance of ASDMs into an organisation. This is proven in Fig.1. Source: Highsmith (2010:78)

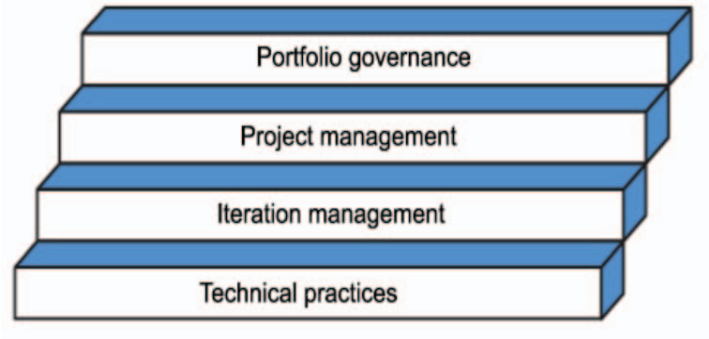

Fig.1. The agile agency framework

In this framework, ASDMs can be placed for each stage as this helps organisations develop hybrid ASDMs to adapt to every project, organisational environment, and requirement. The structure in addition, motivates a lot less adaptability and flexibility at the higher portfolio governance diploma and large at the lower technical practices level. At the portfolio governance level, agencies reflect on consideration on whether or not initiatives address the two vital issues of authorities sponsors, namely, funding and hazard (Highsmith, 2010:79). Governing frameworks and mechanisms can be created to address these two predominant concerns in order to make certain that treasured tasks are furnished to the sponsors with a return on funding interior desirable uncertainty and hazard tolerance levels.

2.1.1. Agile project management model and delivery framework

The APM transport framework is developed to useful resource an organisation's industrial organisation objectives; it "emphasises execution and it is explanatory as a replacement than deterministic" (Highsmith, 2010:82). In order to reap organisation objectives, the framework has to (Highsmith, 2010:81):

- support a disciplined and self-organising mission team;
- promote consistency and reliability as some distance as possible, given the stage of uncertainty there would maybe exist in the project;
- support an adapt, envision and discover culture;
- incorporate practices that help every undertaking phase;
- incorporate learning;
- be adaptable;
- support an obvious view into the process; and
- supply checkpoints for administration for evaluation.

The APM transport framework as shown in Fig. 2 demonstrates the 5 phases of APM. The phases ought to be viewed as one phase flowing into the subsequent and now not like encapsulated separated phases – "the APM terms have been chosen to mean iterative evolution" (Highsmith, 2010:87).

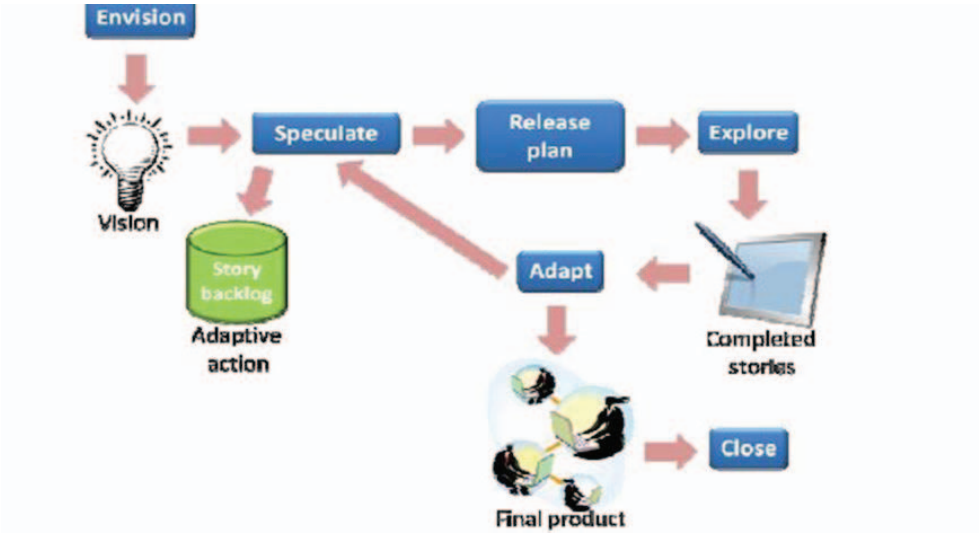

Fig. 2. The APM transport framework

3. METHODOLOGY ANDCONCEPTUAL MODEL

The initial section of the lookup graph carried out the study of literature about the required variables and looking for the hole of lookup as the theoretical basis; The next step is to acquire information of time and fee of land drilling project with depth under 2000 meter, Kemudiaan made risk management venture acceleration analysis with the aid of the use of AHP (Analytical Hierarcy Process) by getting input from specialists to get a clear thinking about threat matrix and danger register prioritisation by using the usage of agile framework [9].

In the risk register, we discussed with the know-how with greater than 10 years' experience to finalise threat matrix and its reference from OSHA, ISO 15001 and ASA4306, then based on literature related to task listing activities, we conduct the different survey from the professional with 10 years journey in venture management oil and gas to select undertaking priority-based totally on every branch with AHP

3.1 Project Management

According to PMBOK (Project Management Book of Knowledge), project management is the application of science and techniques to prepare a project before and during implemented. Project management is divided into five process groups: initiation, preparation, implementation, monitoring, review, and accomplished the project. Managing projects includes identifying stakeholders needs, concerns, and expectations. It designed to be sustainable, intensify management and integrate complex activities to achieve specific goals or add it is recognised as the key enabler of business change and an important contributor to a successful business future (Project Management Institute, 2013).

Project Scope refers to the company's targets in drilling preparation, starting from the annual work plan discussed internally by the company and through government institutions. In this case, Scope management ensures to have the same understanding of drilling, which is conducted. Activities included in project scope management are:

a. The activity of authorising a company to start a project or switch to a subsequent project with the result of an initiation process is a contract agreement which is a key document that formally recognises the existence and provides extensive coverage of a project.

b. Scope planning develops useful documents as the basis for future decision-making, including the criteria for determining whether the project or phase is complete.

c. Definition of scope, deliverables in priority and easy in kelolad.

d. Ensuring project scope and contractor.

e. Control, make corrections, control and monitor project work. In this case, the authority is SKK Migas related to project approval from the technical side, cost and time, after which the company aims to prepare the project schedule and stages clear from the social side, government issues, subsurface issues, operation, safety and also environment[10].

3.1.1 Project Schedule and Cost Management

The main activities that are part of the project schedule management are:

a. Makes sure the activities are aligning with the project goals and target

b. A series of activities align with the support document

c. Estimated time of activity, estimating the number of working periods

d. Developing a schedule, analysing a series of activities, estimating the duration of the activity, and the need for resources to establish a project schedule.

e. Controlling schedules, controlling and managing changes to project schedules.

It includes the activities required to ensure the project is completed in accordance with the approved Budget. The project manager must ensure that the project is well defined, has accurate time and cost estimates, has a realistic cost at the time the approval is made. There are 4 (four) main activities in project cost management, namely:

a. Resource planning, estimating resources (human, equipment, or materials) as well as the number of resources to be used for project activities.

b. Estimate costs, develop approaches or cost estimates of the resources needed to complete the project.

c. Budget cost, allocating overall cost estimates to build a baseline to manage performance on the work unit. Cost control, controlling changes in project budgets.

4. RESULTS AND DISCUSSIONS

An indicative number of significant projects undertaken by KOC during the considered period of 10 years, i.e. 2008 – 2018, segregated under the above-stated categories, can be seen in Fig. 3. The types of projects have been depicted in the graph in the colour code, as shown in the legend. There are many megaprojects underway beyond the stated period.

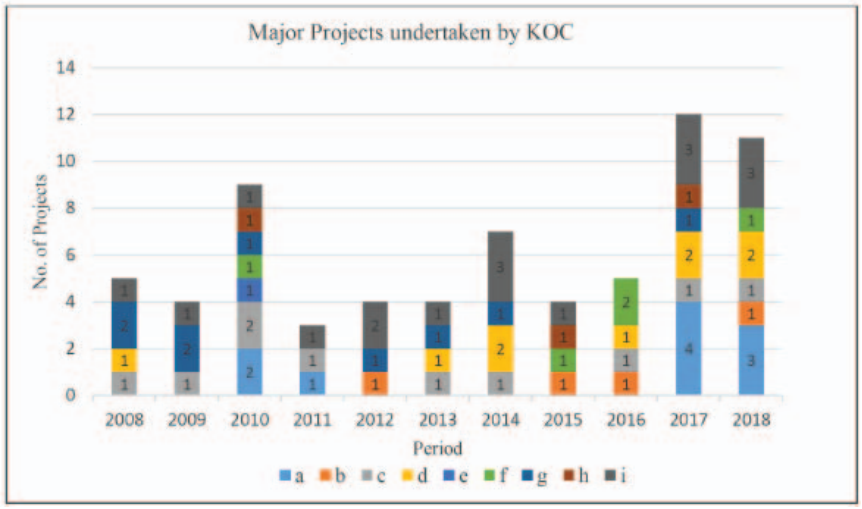

Fig.3. No of the significant project completed

As described above in the individual process elements, there are magnitudes of benefits that can be derived by the suitable implementation of these elements in projects. It can also be seen that some benefits are tangible while others may be intangible in nature, but eventually, they all can have positive impacts on the project performances. These benefits support the project's time, cost, and project management to be more agile to adapt to project needs variations. Historical data from several past projects have been collected to conduct analysis in terms of schedule for the time taken with respect to the current and earlier approaches and utilised to compare with the standard times for these approaches. It can be realised from Fig.4 and 5 that a considerable reduction in time can be achieved after implementing the stated innovative and strategic practices.

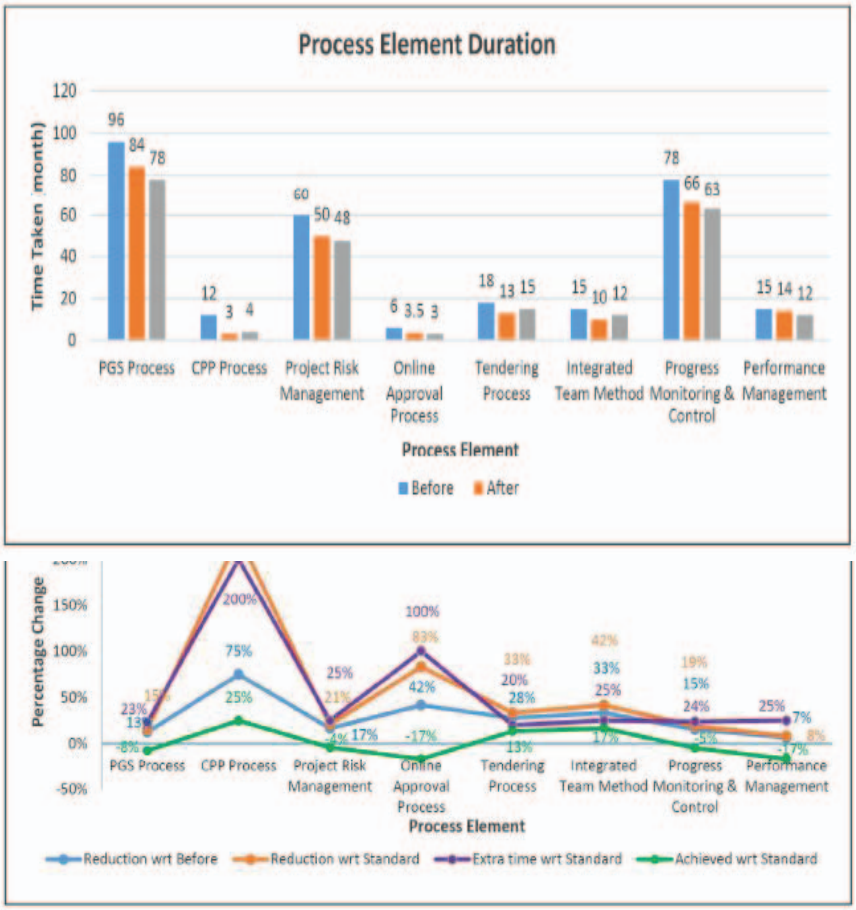

Fig.4. Process elements duration

5. CONCLUSION

This research made sense why the ability to cope with uncertainty is relevant for business organisations in the oil and gas industry, especially as the nature of their operations is, by default, challenged by a diverse set of hazards and risks. Thus, this study had two-fold aims. First, it proposed to explore whether specific factors affect ERM implementation. Secondly, it probed the findings that emerged from data analysis to develop an implementation framework applicable to Oil and Gas organisations. By relating to the last 20 years, ERM had progressed significantly, impacting organisations' differentiated identity by affecting the particular governance processes. It has been argued that despite this progress, all contributions made to the literature relating to ERM have only been descriptive, being mainly visionary rather than implementational.

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The Impact of Maintenance Planning on Large Project Management Performance

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Abstract— Structured methodologies and tools for the tailored design of factories are adopted by suppliers of manufacturing systems but usually discontinued after the design phase. The use of an ontology-based virtual factory, continuously synchronised with the real plant, is proposed to guarantee digital continuity and enable in-situ simulation during the operating phase. This digital counterpart of the system can be used for integrated shop-floor simulations to assess production and maintenance planning decisions' future impact. An industrial application is provided in the context of roll shops, i.e., systems devoted to the grinding of cylinders for rolling mills.

Keywords: *Communication planning, tools, Factors affecting the quality, method*

1. INTRODUCTION

A project is defined as a set of interrelated tasks to be executed over a fixed period and within certain cost and other limitations. Therefore, a project consists of a set of activities to be done until the project is achieved. Nevertheless, the project needs planning, organising, leading, and controlling to make the process flow smoothly and ensure no delay in achieving the aim within the predefined period. This will be more significant when it comes to megaprojects, consisting of countless activities and tasks in parallel or sequentially. Large projects involved with huge number of activities. Those activities are planned in a specified period. The activities of the project have to be planned carefully and effectively. The project usually involved with machines, equipment, labor, processes and not all these elements may be available all the time. In reality so many obstacles associated with the execution of the project activities, such as vacations of staff, resources availability and planned maintenance [1]. Machines are subject to deterioration due to their use and exposure to the process and environmental conditions. This deterioration requires to be duly taken care of by various maintenance skills and techniques at minimum cost so that the required use of facilities can be continued and service life extended to the point where maintenance costs become more than the replacement cost [2]. There are two types of maintenance planning which are (i) planned and (ii) unplanned maintenance. The planned maintenance can have less effect on the project management performance because the maintenance is already scheduled within the project activities. Fig.1 depicts the different types of maintenance available in managing the machines and equipment [3].

Large projects consist of numerous activities and involve high investment in the equipment, processes, and operations. For successful management of the project, planning is a very important step to be taken because it will decide what activities to be executed first and how the flow of activities will be executed. Nevertheless, the maintenance planning for machines and equipment involved in the project will have an impact on project management performance.

The effect of maintenance planning will be critical when some of the equipment suddenly failed. It will affect the execution of the current project activity and preceding one and the overall project completion time will be longer. Therefore, higher investment cost will be borne by the project holders, which is undesirable. This also will have an impact on the project management team [4]. There are many causes for planned activities interruptions.

An activity may be interrupted because some renewable resource becomes unavailable during a rest time or a planned maintenance operation, which will create a scheduling problem [5].

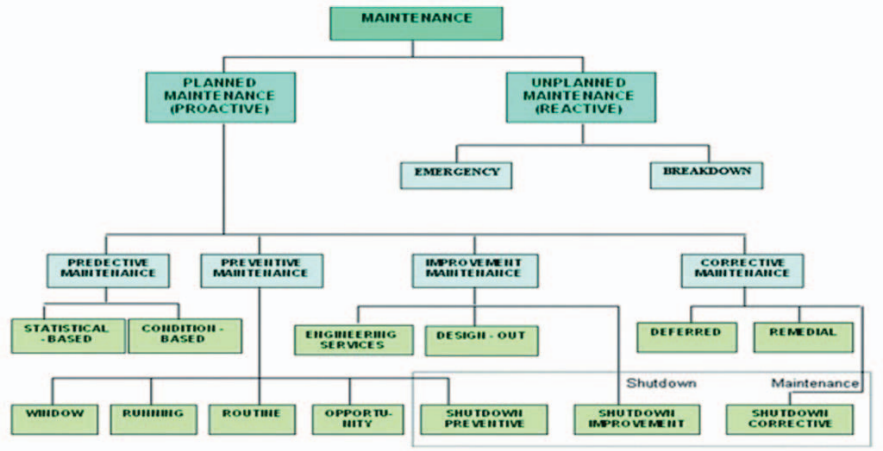

Fig.1.Different types of maintenance planned and unplanned [3]

2. COMMUNICATION PLANNING FOR PROJECTS

Project-communication management is recognised as a key project-management knowledge area by the Project Management Institute (PMI, 2008: 43). Part of the communication management process is communication planning, which can be defined as the process of "determining the project-stakeholder information needs and defining a communication approach" (PMI, 2008: 243)[6]. This section considers the various strategies, mechanisms and tools for communication planning in the project environment.

According to Yates (2006: 77), communication planning tends to occur reactively to communication needs, as opposed to occurring proactively – even though it was found that formal communication plans do facilitate the communication process (Carvalho, 2008: 1282)[7]. Project communication planning starts with identifying various parties' needs and then focusing on the sharing of information, providing feedback and managing the stakeholders (Carvalho, 2008: 1281).

Communication planning is closely linked to stakeholder management. According to the PMI (2008: 261), stakeholder management is a process of communicating and working with the stakeholders to meet their needs and resolving issues as they occur; and it includes:

- Managing stakeholder expectations and keeping them engaged.
- Anticipating and addressing concerns that might later become problematic.
- Resolving knowledge issues.

2.1 Communication tools

The quality of team communication is highly dependent on the communication acts of the individual team members, the use of their preferred communication media, and the access to easy-to-use tools (Otter and Emmitt, 2007: 409)[8]. There are many tools available to project teams, and, in general, the more tools used by the group, the more successful a team is likely to be (Ziek and Anderson, 2015: 791). This section considers the various tools available to project teams, taking into account their potential benefits and shortcomings. In the project environment, project team members may find themselves working in separate locations (remotely located) or together (collocated) with other team members (Lockwood, 2015: 126, Daim et al., 2012: 200). Choosing appropriate communication tools is thus a significant consideration for project managers; as effective communication tools must cover both synchronous (real-time) and asynchronous (delayed) communication, where team members may be either remotely or collocated (Gorse and Emmitt, 2007: 1197).

Nicholas and Steyn (2012: 443) propose that project-management information systems (PMIS) be used as tools to enable both synchronous and asynchronous communication, defining them as "systems for collecting, organising, sorting, processing, and disseminating information". Practical examples of PMIS for project teams

would include online or network[9].

2.2 Factors affecting the quality of communication

According to Stempfle and Badke-Schaub (2002: 493), even when communication tools are successfully implemented, the nature of the communication may still be inadequate. This section identifies those factors that have an impact on communication in project teams, and it considers strategies for how to manage them. Communication is described as the effective transmission of information (Barker, 2010: 1) or, as the process by which information is exchanged and understood by two or more people, usually with the intent to motivate or influence behaviour (Cunningham, 2014a: 188). The ability to communicate efficiently and effectively is one of the most important skills required by a project manager (Ziek and Anderson, 2015: 789)[10]. The communication process involves the following basic elements: a sender, a receiver; the message; a channel; coding/decoding and feedback (Carvalho, 2008: 1280).

The transmission model of communication, favoured by project managers (Ziek and Anderson, 2015: 788), starts with the information transmitted by the sender; and it then is received by the recipient (Barker, 2010: 2). This is, however, an over-simplified view; as before the message can be transmitted, the sender must first perceive a need to communicate, resulting in the sender having to encode a thought. In other words, the sender has to pay attention, understand and implement what is understood in context (Barker, 2010: 4). This encoding process requires a great deal of skill, which includes writing, speaking, reading, listening and reasoning skills (Cunningham, 2014a: 191)[11].

3. RESEARCH DESIGN AND METHOD

3.1 Method

The research project attempted to understand the way that high-performance team members perceive project-communication planning; how they feel about communication methods; and how they would prefer to communicate. The focus of the study was thus to explore personal experience and feelings by communicating face-to-face with the team members. The themes explored and the use of interviews to collect the data aligned with a qualitative approach to the research study. This approach is supported by Leedy and Ormrod (2005: 95), who explained that qualitative methods are appropriate, where the purpose of the research is to explore and interpret, and where the researcher will be searching for themes and categories, based on the words of the people involved.

The research sought to develop a deep understanding of the research questions; as they pertain to Aurecon. Considering the setting of the research study, a case-study framework was adopted to guide the research process. This type of research design is useful for "generating an understanding of and insight into a particular instance, by providing a thick, rich description of the case, and illuminating its relations to a broader context" (Rule and Vaughn, 2011: 7)[12].

This research project made use of a semi-structured interview process in order to collect the data. The semi-structured interview type was selected to ensure that the sub-questions were addressed – without making the interviews too rigid. This method also allows researchers flexibility in how the interviews are conducted, as opposed to structured approaches [13].

3.1.1 Orientation sessions, communication and planning

For purposes of orienting both the employees of the company and the facilitators of change, i.e. the Change Management consultants, the following activities took place:- change management detailed planning sessions were organised change management consultant's induction (1,5 days) into the region took place change management consultants (CMC) facilitated orientation sessions with the management team and end-user groups further, the company developed means of communicating implementation activities (regular briefs, meetings, posters, etc.) organised visits to/from implementing other companies for learnings conducted role clarification sessions with the company's enterprise resource planning system trainers, super-users and champions

3.1.1 Analysis of data collected

The results of the survey were analysed by summing responses (strongly agree, agree, neutral, disagree and strongly disagree) by groups, that is, management, super users and the shop floor. Thereafter, the percentages of responses within that group were calculated. Thus, the percentage of results quoted relate to each group individually. Where comparison is drawn, it is done purely on how each group responded, not as a sum of all responses by all groups in a specified category of questions. Percentage figures of the results were rounded off to the nearest whole for uniformity.

4. RESULTS AND DISCUSSION

There is a contradiction with regards to the training and development of career paths for maintenance personnel. On the one hand all seem to think that maintenance personnel are well trained, yet there are no clearly defined career paths being implemented. The general perception that is painted is that of management, who seem to believe that maintenance practices are not that good, table 1. The super users, on the other hand, are more optimistic about maintenance practices. More often, the shop floor agreed with the view of management. The responses (in rounded percentages) given about perceptions on maintenance practices are shown in table 1.

Table 1. Perceptions of maintenance practices

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Management	0	21	33	33	13
Super users	0	3.7	23.8	55	17.5
Shopfloor	3	11	42	39	5

A concern may also be raised on the high number of neutral responses from the shop floor, see fig. 2, compiled from the data obtained from the research survey, appendix 2. The Enterprise Resource Planning system was analysed in terms of its capability, effectiveness, its use as a management tool, and its handling of errors from the data collected and computed. The system's capability addresses what the system is able to do as perceived by management, super users and the shop floor.

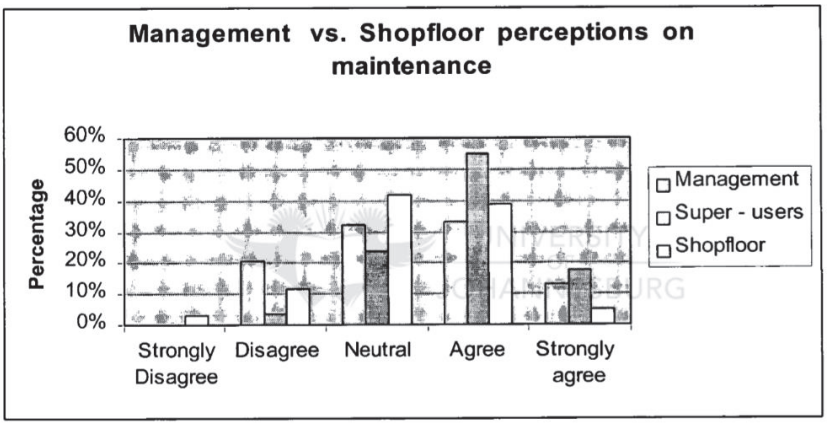

Fig. 2. Perceptions of Management, Superusers and Shop floor on maintenance Practices

From the survey, the following results were obtained; 40 % of management, 40 % of super users and 50 % of shop floor agree that the system is capable, fig. 3. This result is confirmed by the study conducted by Forrester, who asserts that today's Enterprise Resources Planning systems, due to some extent, meet current requirements of process environment.

The fact that 20 % of each category of people surveyed disagrees with the statements in general confirms that the system still requires improvement. The system effectiveness section of the survey addresses an Enterprise Resource Planning system's ability to carry out maintenance activities. In this section 60 % of management respondents, 10 % of super users and 50 % of shop-floor agree with the statements, fig 4. It is notable that 40 %

of the super users strongly agree with the statements. One may conclude from this that the system is effective in supporting maintenance activities.

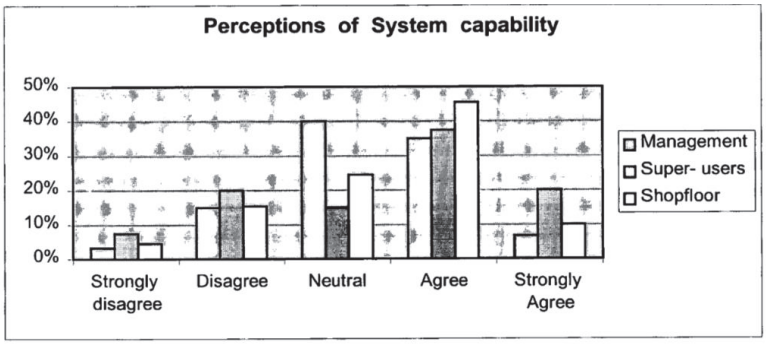

Fig.3. Enterprise Resource Planning System capability

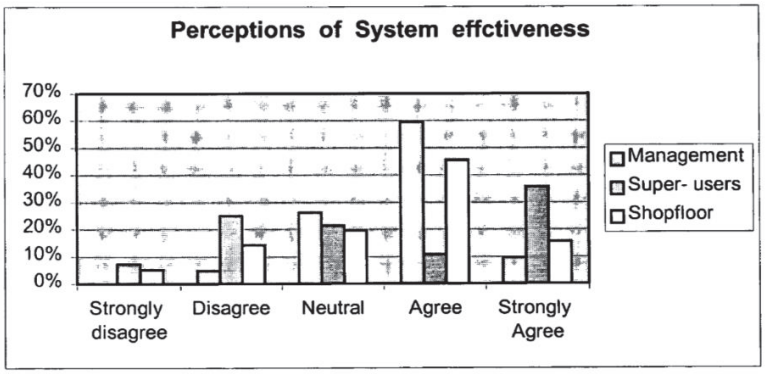

Fig. 4. Enterprise Resource Planning System effectiveness

The results of whether those who use the system view the system as a management tool are interesting in that only the shop floor agree with the statement with 50 % and a further 30 % of them strongly agreeing with the same statements, fig. 5. Only 30 % of super users and 40 % of management agree with the statements. On the other hand, 30 % of management and 30 % of super users were neutral on these statements. This is a worrying factor since both management and super users are at the management level and it seems the system does not meet their requirements.

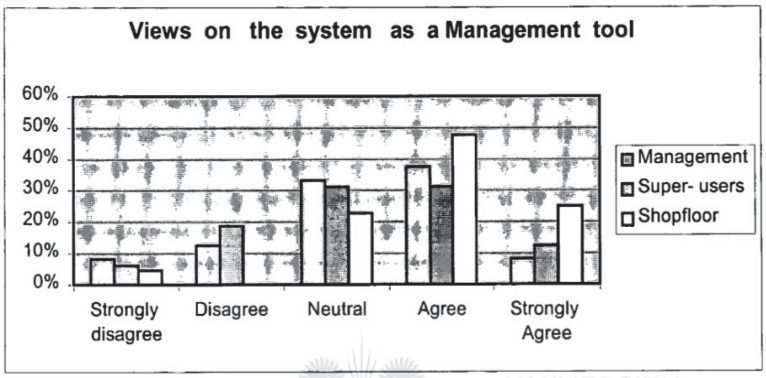

Fig. 5.Enterprise Resource Planning system a management tool

In as far as the system's capability to handle errors is a concern, there seem to be mixed feelings across the board. 40 %, 30 % and 48 % of management, super users and shop floor, respectively, agree that the system can handle the errors as shown in Fig. 6.

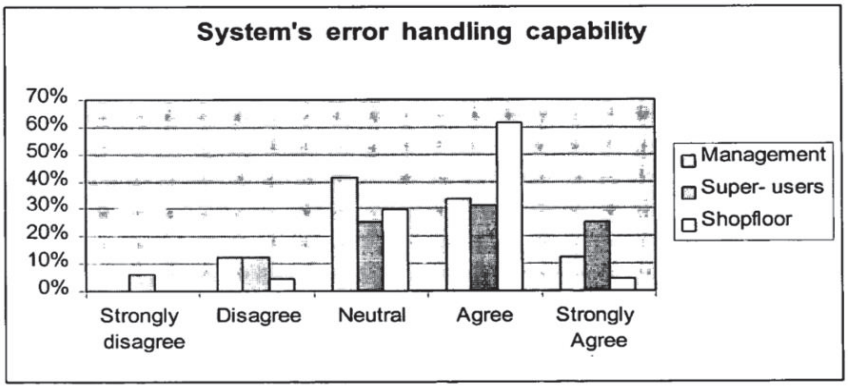

Fig. 6. System's capability to handle errors

5. CONCLUSION

Form the research survey it has crystallised that the integrity and effectiveness of the maintenance management software system require further improvement, which should be done by developers of Enterprise Resource Planning systems. The current Enterprise Resource Planning systems can not meet a fundamental requirement of a process environment which is that of being proactive in order to be competitive - the Enterprise Resource Planning systems are reactive and are not intelligent.

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Automated Farming System Using Distributed Controller: A Feasibility Study

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Abstract— Agriculture is fundamental to a human being because it has itranted humanity's evolution. It is among the essential activities that ensure the development of the human being. So, it is capital to ensure good work and the efficiency of agricultural production. Thus, the research is focused on the domain of agriculture automation to increase the agriculture production yield with less water consumption and less risk in Africa, particularly in Senegal, where agriculture delays reaching food self-sufficiency because of rudimentary materials. The farmers are using a hilar, plough, and hoe for doing their daily tasks. The watering can still be used to water a large area of crops and is done randomly. The chemical pesticide is done manually using a manual sprayer, which causes enormous risks of diseases to the farmers and destroys the field and even the crops. This thesis describes an approach to automated farming by the use of a Sprayer Robot based on Arduino. Besides the Sprayer Robot, the paper also presents an automated irrigation system based on the Senegalese climatic parameters and soil textures through CROPWAT and CLIMWAT. The automatic irrigation system is done with a programmable logic controller, the master controller of the overall design, including the Sprayer Robot. Moreover, a SCADA graphical interface is also implemented for the monitoring of the whole system. The project, tested in simulation with the CROPWAT and CLIMWAT data, could give no reduction yield if applied and also reduced risk of diseases due to chemicals.

Keywords: *Communication planning, tools, Factors affecting the quality and method*

1. INTRODUCTION

This research will focus on agriculture automation and will ensure the easiness of using farming in advanced technologies. Facing an increase in its population and the food insecurity which threatens the national territory of Senegal since 2012, the

This research will focus on agriculture automation and will ensure the easiness of using farming in advanced technologies. Facing an increase in its population and food insecurity that threatens Senegal's national territory since 2012, the Senegalese government had set up a lot of programs for the development of agriculture that would help achieve food self-efficiency in Senegal. But in fact, almost all of these programs have not succeeded in reaching their targets because of several reasons that the researcher will develop in the problem statement section (DAPS, 2013).

Besides, in poor countries, agriculture is underdeveloped compared to western agriculture. Particularly in Senegal, the rural population represents 55% of Senegal's total population, estimated at 13.5 million in December 2013. The agriculture- the fishing sector is an important economic sector; it contributes 14% of GDP and employs around 50% of the labour force (Havard, 2015). Despite this, more than half of rural people, usually tiny subsistence farmers, live below the poverty line and 30% are affected by food insecurity (Havard, 2015). Agriculture is based on cash crops (peanuts, cotton, horticultural products in part) and food crops (mainly cereals). Most of these are seasonal and rain-fed, centred on the wintering period. But irrigated areas, representing only 5% of the agricultural area, and off-season production tend to develop. Climatic hazards, declining soil fertility and pest attacks have a substantial impact on production (DAPS, 2013)

Motor pump use also exists for agricultural cooperatives and a few peasants (DAPS, 2013). Irrigation is done at intervals of time according to the appreciation or experience of the farmer. No information on climate or soil is

considered. Thus, it is obligatory to update this field by doing some research to come out with some good solutions. Globally, mechanization is a crucial input for agricultural crop and has been neglected by many countries, especially in Africa (FAO, 2019). Increasing the power supply to agriculture means that more tasks can be completed, and more significant areas can be farmed to produce greater quantities of crops while conserving natural resources. Applying new technologies which are ecologically friendly allows farmers to harvest crops more efficiently by using less power.

So, this research is to help the agricultural policies in Senegal. It is known that farming is needed to quickly reach the food self-efficiency that has been proceeded many years ago without satisfactory results. Therefore, one of the purposes of this research is to figure out some ways to lead the farmers to do their jobs better by modernizing it while showing the African governments that mechanization agriculture does not only mean making a big investment in tractor or other machinery.

2. METHODS

The research starts with a deep analysis of problems and a literature review. After the period of the literature review, the period of data collection will come through one Senegalese farm field, which can be used as a witness. The study will provide information for developing the irrigation system and the distance between lines of the crop. Then, the connexion will be established with the Senegalese Institute of Agricultural Research to get the needs of each type of crops concerning a specific region and the dosage of chemical preparation that can eliminate weeds and the needs of water.

Once all of the above is done, the study's start will be made by the robot's conceptual design and programming, which can be spraying the pesticide in two opposite directions. First of all, we have the designing process of the robot, which starts by setting its dimensions. Afterwards, we will choose the different types of materials we will need and create a mechanical part of the design. The electrical component consists of selecting the motors, power supplies, sensors, and wiring diagram. The last part of this process consists of choosing the controller and building up the robot.

Secondly, we will design the irrigation system by choosing pumps and pipes based on the depth of the well and the distance from the well to the plant. The study of humidity, temperature, and wind speed sensors can allow us to get data from the soil and the environment for commanding the water pump. Thus, resolve the problem of manual watering. This part will be done essentially in software by programming and simulation. After that, it will be the stage for the researcher to come out with the PLC's choice and its components. To do the programming and the research starts with a deep analysis of problems and literature review. After the literature review period, the period of data collection will come through one Senegalese farm field that can be used as a witness. The study will provide information for developing the irrigation system and the distance between lines of the crop. Then, the connexion will be established with the Senegalese Institute of Agricultural Research to get the needs of each type of crops concerning a specific region and the dosage of chemical preparation that can eliminate weeds and the needs of water. Once all of the above is done, the start of the study will be made by the conceptual design and programming of the robot, which can be spraying the pesticide in two opposite

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stage for the researcher to come out with the PLC's choice and its components. To do the programming and then examine each system's interconnection in the PLC and its flows. The work of the irrigation system will be stimulated through the PLC. Finally, the researcher will implement the monitoring interface by SCADA and allow the farmers to set the concerning plant parameters and know what happens in their farms. The methodology flowchart can be seen in Fig. 1.

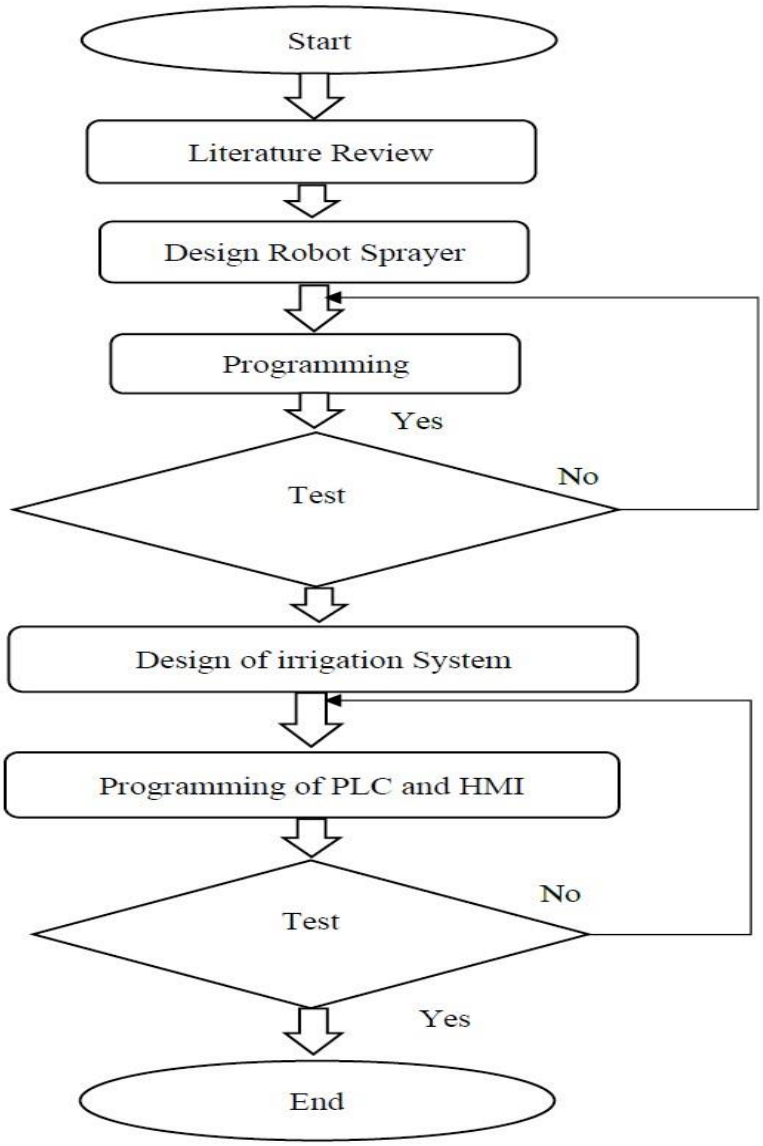

Fig. 1. System flow chart

3. CONTROLLER DESIGN

The control system is a mean of allowing to increase the competitively of a product established by the system. It can improve productivity, enhance the flexibility of the process, increase the quality of the product, adapt to particular contexts, and increase security. For that reason, the control system is a crucial task in order to achieve the purpose of this project. The control system of a process involves transferring some or all of the coordination tasks previously performed by human operators to a set of technical objects called the command part. The control part memorizes the know-how of the operators to obtain the continuation of the actions. This is to be carried out on the materials of work in order to elaborate the added value. It exploits a set of information taken from the operative part to develop the succession of orders necessary to obtain the desired actions. The operative part is equivalent to the process and the physical machine. The control part is equivalent to the automation and the programmed system.Figure 2 illustrates the structure of a control system.should be absolute

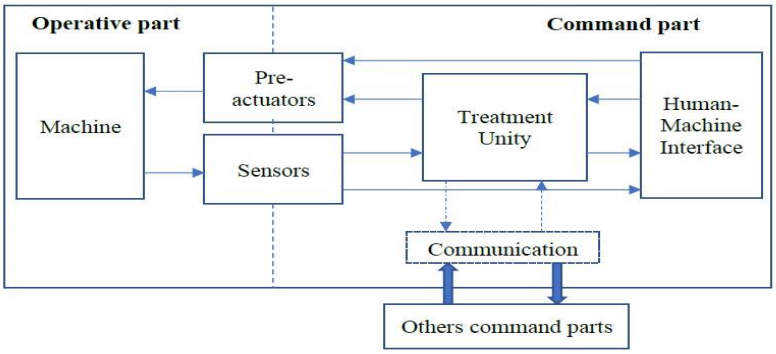

Fig. 2. Structure of a control system

The system first checks the highest level of water inside the tank. If the water does not reach the highest level of the tank, the PLC turns on the pump until the highest level is reached. After reaching this level, it turns off the pump. Then, the PLC checks the soil moisture sensors to see if the management allowable depletion is reached. The controlled valves are opened until the soil moisture sensor reaches the field capacity and the valves are closed.The temperature and humidity sensors will allow us to have information about when the next rrigation will occur.

Figure 3 depicts the working principle explained in this section and Figure 4 the block diagram connections of the irrigation.

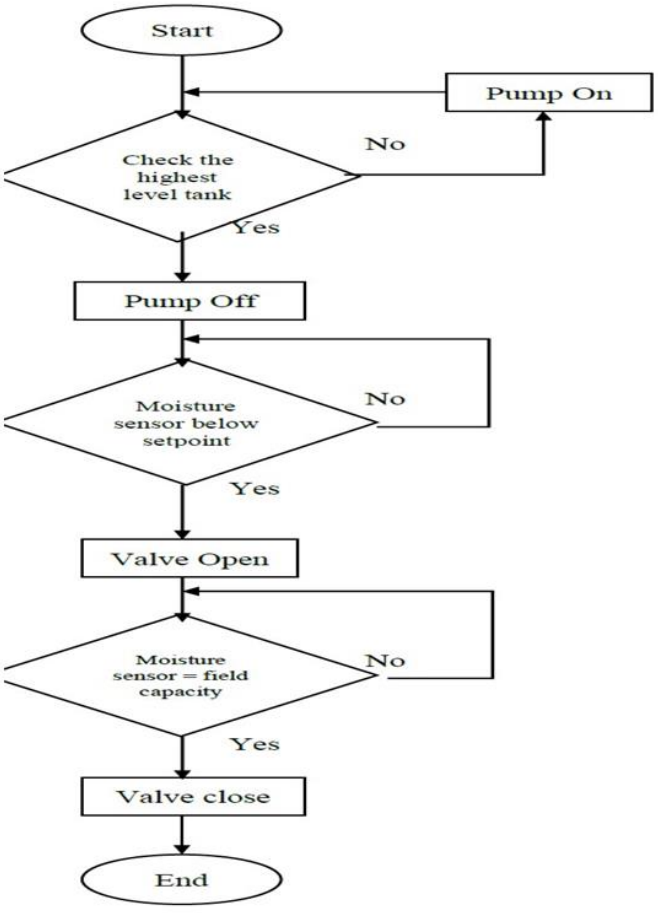

Fig. 3. Control algorithm flowchart

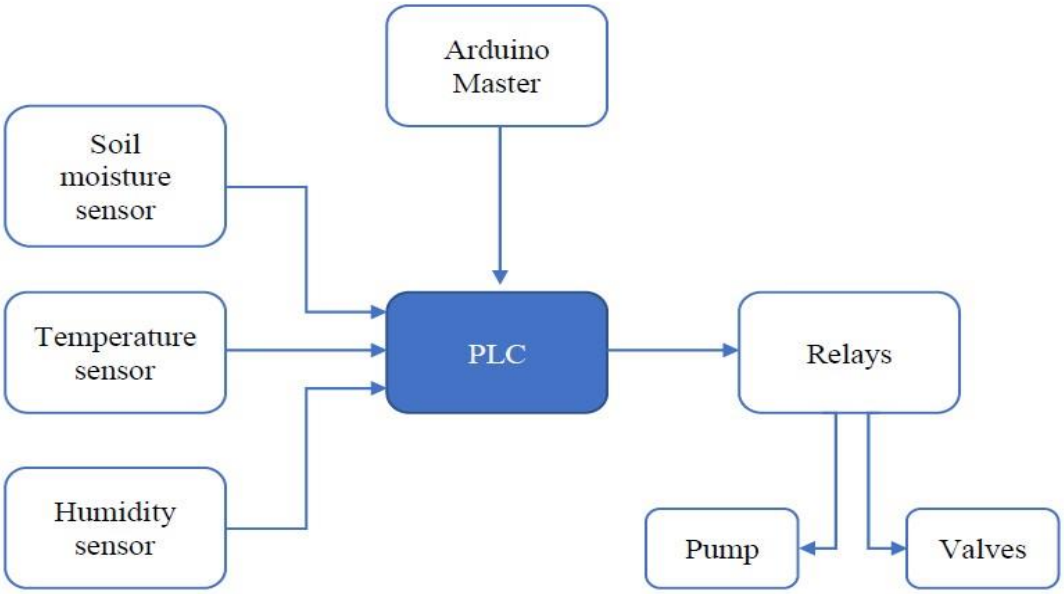

Fig. 4. Block diagram of the irrigation system

Table 1 Input/output assignment

Name	Address	Type
CMD_close_valve	%M108	EBOOL
CMD_open_valve	%M107	EBOOL
CMD_Pump	%M106	EBOOL
FD_Setpoint	%MW10(	REAL
FD_Setpoint_mais	%MW15(	REAL
FD_Setpoint_tom	%MW16(	REAL
FD_Setpoint_veg	%MW14(	REAL
High_level_tank	%M105	EBOOL
Humidity	%MW60	REAL
Input_humidity	%MW50	INT
Input_in_temp	%MW40	INT
Input_soil_moisture	%MW30	INT

Table 2 Input/output assignment

Low_level_tank	%M103	EBOOL
MAD_Setpoint	%MW90	REAL
MAD_Setpoint_mais	%MW120	REAL
MAD_Setpoint_tom	%MW130	REAL
MAD_Setpoint_veg	%MW110	REAL
RobotRun	%M102	EBOOL
Soil_Moisture	%MW70	REAL
StartRobot	%M100	EBOOL
StopRobot	%M101	EBOOL
Tank_1_Close	%M121	EBOOL
Tank_1_Enable	%M123	EBOOL
Tank_1_Level	%MW10	REAL
Tank_1_Open	%M120	EBOOL
Tank_1_Power	%MW20	REAL
Tank_1_Valve	%M122	EBOOL
Temperature	%MW80	REAL

4. RESULT

Regarding the robot, in the graphical interface, the user can order to run or stop the robot through the button StartRobot and StopRobot. The symbol in the robot box in figure 5 shows the robot's status.

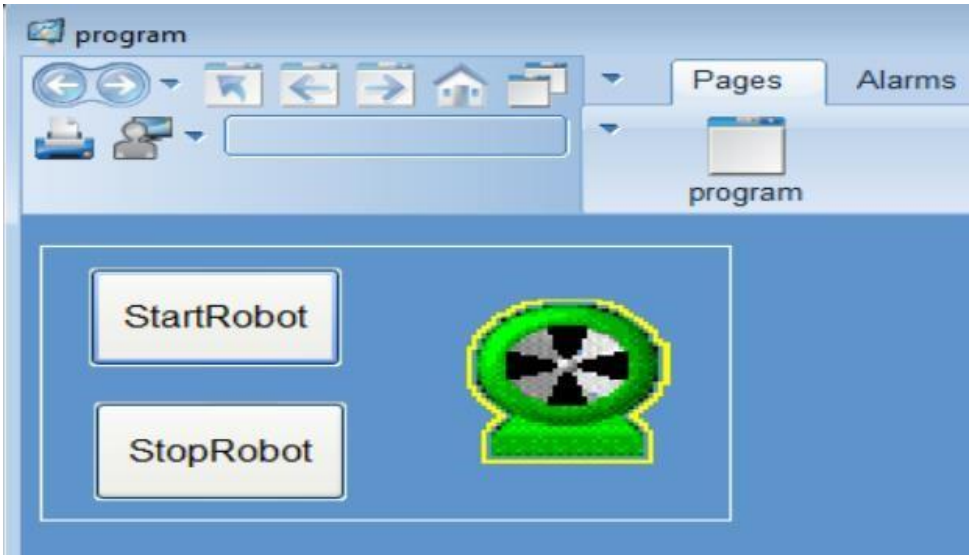

Fig. 5. When the robot is on start mode.

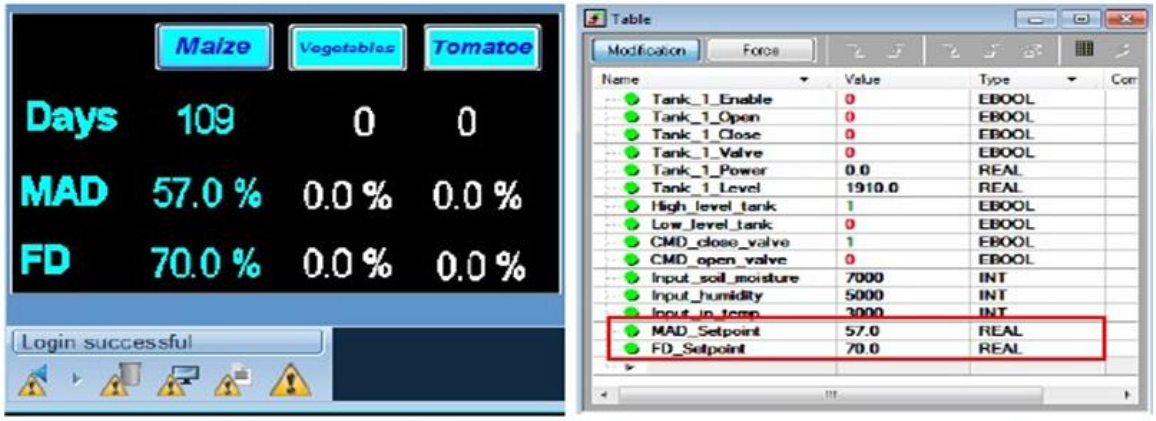

Fig. 6. Maieze SCADA database box and PLC input/output table

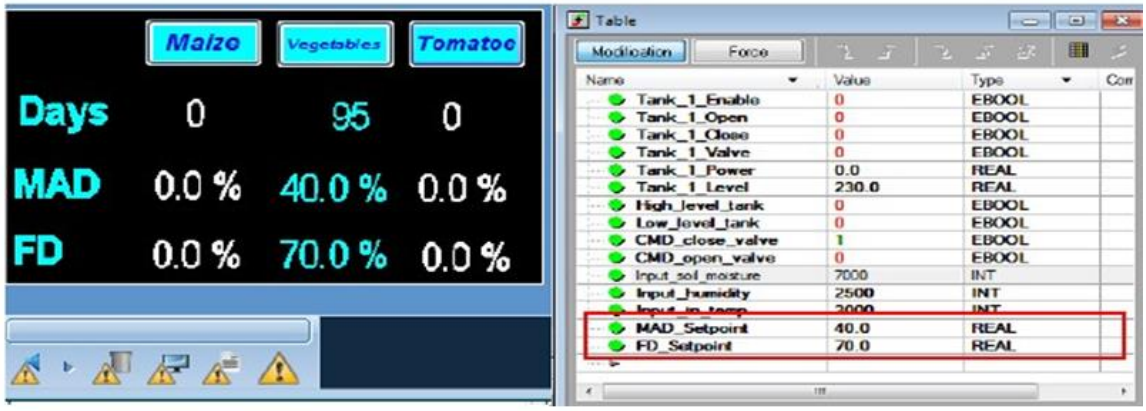

Fig. 7. Vegetable SCADA database and PLC input/output table

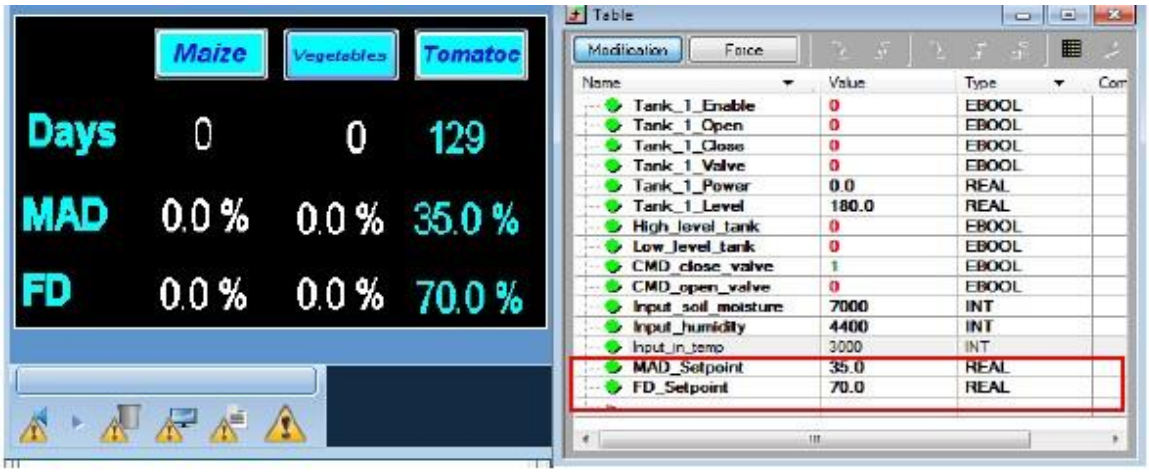

Fig. 8. Tomato SCADA database and PLC input/output table

From the results discussed above, it can be assessed that the master controller of the whole automated farming system has satisfactory performance, even it still remains some option that can be improved. The system loads perfectly the data from the database but it requires the database file to be launched before in the same computer.

The SCADA interface gives a perfect representation of the automated farming system and from the entire tests done, it can be resumed that the automated farming system is ready to be implanted in a practical situation.

5. CONCLUSION

The research contributions are summarized as follows. The design of a Spraying Robot can evolve in outdoor farming by using railways and no GPS tracking as guidance. The method of a graphical interface in irrigation is connected with a databas that does not need an internet connection to work. Implementation of Input/output – Bluetooth communication between the robot and the PLC. There were several challenges faced during this research, such as:

a) Establishing communication between the PLC and the sprayer robot.

b) To link the database with the SCADA by the use of Cicode.

c) The connection link between the two Bluetooth modules respectively for the robot.

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Ferroelectric behavior and NCFETs - TCAD Simulation

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Abstract— With the miniaturization of transistors, the current leakage also increases due to the increasing tunnelling effect. Plus, Boltzmann's tyranny limits the subthreshold swing to be best and ideal at 60 mV/decade. Due to these, the power consumption in transistors keeps soaring up. Therefore, in this paper, the Negative Capacitance Effect Field Transistor (NCFET) is discussed as it possesses excellent potentials in reducing the power consumption in transistors. The negative capacitance induced in NCFET enables the internal voltage amplification and reduces the required voltage for the transistor to operate, and therefore, the power consumption is reduced. The literature reviews are done to gain knowledge on the structure and behavior of the NCFET. Next, the process and device simulation of NMOS are studied using Silvaco TCAD to get the idea of developing a circuit simulator model of NCFET. After that, we developed the circuit model of NCFET and MOSFET. Next, the ferroelectric parameters are varied to study how it will affect the ferroelectric material's polarization and capacitance. The ferroelectric thickness and source-drain doping concentration of the proposed NCFET model is also varied to study the NCFET behaviors in peak current, subthreshold slope, saturation current and saturation slope. Lastly, the performances of NCFET and MOSFET are compared. It is found that the NCFET has better performance as compared to the MOSFET as the NCFET can achieve a steeper subthreshold slope.

Keywords: *MOSFET, NCFET, Subthreshold slope, Ferroelectric, TCAD*

1. INTRODUCTION

The power consumption issue has merged to become a significant concern in CMOS technology. The Negative Capacitance Field Effect Transistor (NCFET) introduced in 2008 by S. Salahuddin is a promising candidate for solving the issue [1]. The negative capacitance exhibits by the ferroelectric in NCFET enables the voltage gate applied to be amplified, thus reducing the power consumption while maintaining the transistor's performance. The negative capacitance is utilized to overcome the Boltzmann mechanics that limit the subthreshold swing at 60 mV/decade. Many NCFET related works have been conducted to study the NCFET performance under different conditions [2-6].

Over the last few decades, shrinking the transistor is one of the implemented alternatives to achieve higher speed, improved power consumption and integration density [7]. However, after considering the conflicts mentioned above, it is worth mentioning that merely downsizing the transistors is no longer applicable. This is where the Negative Capacitance Field-Effect-Transistor (NCFET) is discovered to be one of the promising solutions to solve the issues.

In this paper, ferroelectric behavior and NCFETs behavior will be analyzed using TCAD simulation to observe the devices' performance.

2. BACKGROUND OF NEGATIVE CAPACITANCE

Electrostatic energy density in a dielectric material is given by

$$w = \int_0^D E(D)dD \tag{1}$$

where E is the electric field and D is the electric displacement field. The relationship between *E* and *D* can be

either linear or nonlinear. The total energy stored in a capacitor is given by

$$w = \int_0^Q V(Q)dQ \tag{2}$$

Where V is the applied voltage and Q is the charge stored in electrodes. The stored energy can be shown in Fig. 1a for a linear positive capacitance, C=dQ/dV, and energy stored in a capacitor is given by $w = CV^2/2$. However, for negative capacitance (NC) material, Q and V are not linear for all applied voltage, as shown in Fig. 1(b). Capacitor with negative differential capacitance dQ/dV < 0 due to dD/dE < 0.

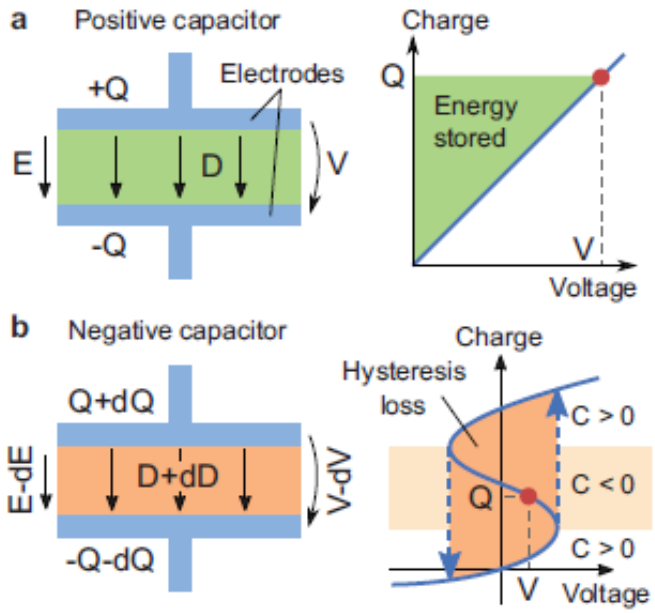

Fig. 1. (a) Positive and (b) Negative capacitances C-V characteristics [8].

2.1 Ferroelectric negative capacitance to reduce subthreshold swing

MOSFET with simple capacitance divider as shown in Fig. 2. V_G is the applied gate voltage, C_{ox} and C_S are the oxide and semiconductor capacitance, respectively.

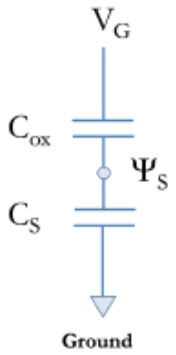

Fig. 2. A simplified view of a MOSFET as a capacitive divider.

The surface potential $\psi_s$is related to gate voltage as

$$\psi_s = \frac{C_{ox}}{C_{ox} + C_s} V_G \tag{3}$$

The surface potential and gate voltage is denoted by "body factor", m and is given by

$$m^{-1} = \frac{\delta\psi_s}{\delta V_G} = \left(1 + \frac{C_s}{C_{ox}}\right)^{-1} \tag{3}$$

The subthreshold slope (SS) is defined as $\delta V_G / \delta log_{10}(I_D)$ which can be written as

$$SS^{-1} = \frac{\delta log_{10}(I_D)}{\delta V_G} \frac{\delta log_{10}(I_D)}{\delta \psi_s} \frac{\delta \psi_s}{\delta V_G} = \frac{1}{log_{10}} \frac{q}{k_B T} \frac{1}{1+\frac{C_s}{C_{ox}}} \tag{4}$$

It can be seen that the functional form of m and SS, negative oxide capacitance amplifies the surface potential relative to the gate voltage, thus reducing the body factor below m and reducing SS slope below 60mV/decade. Ferroelectric materials are used to realized negative capacitance. A ferroelectric is defined as a material that exhibits a spontaneous polarization that can be reversed with an applied electric field. The polarization characteristics of ferroelectric materials are shown in Fig. 3.

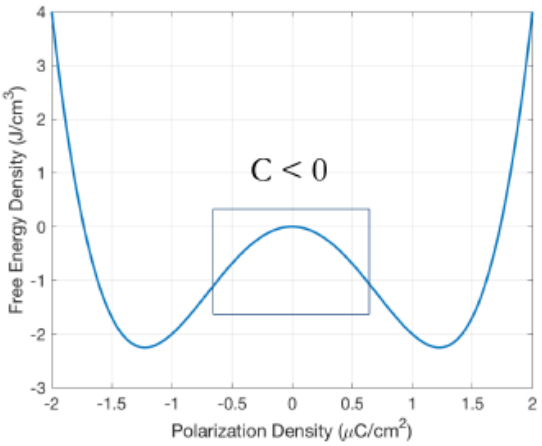

Fig. 3. Polarization density of ferroelectric material with a distinct negative capacitance zone.

Recently, researchers capture an image of negative capacitance in action [9]. They have shown fundamental, atomistic insight into the physics of negative capacitance. They have shown NC behavior in $SrTiO_3/PbTiO_3$ heterostructure system.

2.2 NCMOSFET

Fig. 4 shows the realization of NCMOSFET proposed by Kobayashi et al. and shows the performance of the device. The structure of a NCFET is the same as a MOSFET, except that the gate insulator is replaced by a ferroelectric material, as shown in Fig. 4.

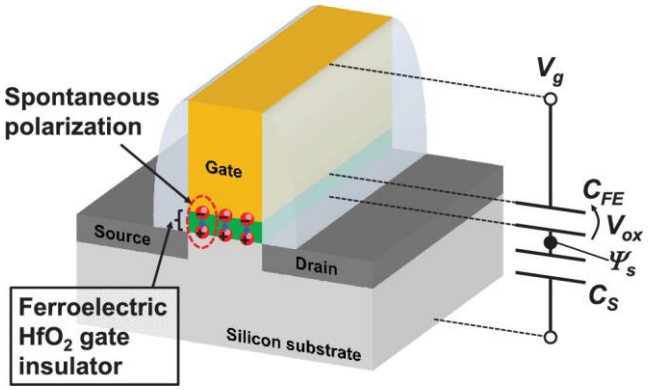

Fig. 4. A schematic of a NCFET with a ferroelectric gate insulator. A ferroelectric MOS capacitor is modeled by series connection of ferroelectric and channel capacitance [10]

Alam *et al.* recently critically review the progress on negative capacitance [11]. He has summarized the findings in Fig. 5.

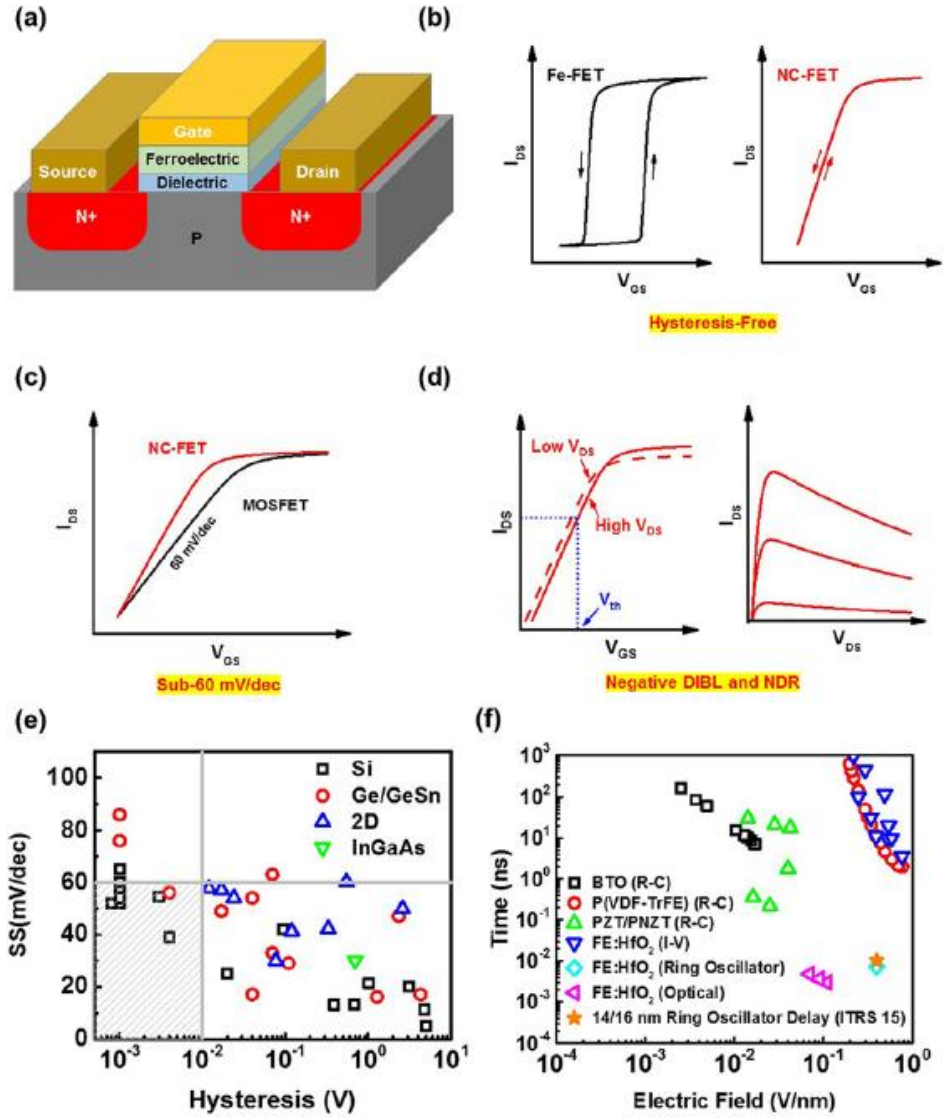

Fig. 5. (a) Schematic image of a NC-FET with ferroelectric and conventional dielectric as the gate stack. (b) The fundamental difference in transfer characteristics of a Fe-FET versus a NC-FET which has an anti-clockwise hysteresis or zero hysteresis, respectively. (c) Expected steep-slope less than 60 mV/dec at room temperature for a NC-FET. (d) Expected negative DIBL and negative drain resistance for a NC-FET. (e) Summary of the reported representative data in the literature in terms of SS versus hysteresis in transfer characteristics (SiGe/GeSn, 2D, InGaAs). SS is plotted as the larger SS in forward and reverse gate sweeps and only when both are available. Data without explicitly reported hysteresis are plotted with 1mV hysteresis. (f) Summary of reported switch times of representative ferroelectric films versus the electric field by different characterization methods in the literature (BTO (R-C), PZT/PNZT (R-C), P(VDF-TrFE) (R-C), FE:HfO2 (I-V), FE:HfO2 (ring oscillator), FE:HfO (optical)) [11].

The author also mentioned different types of experiments to support negative capacitances.

3. RESULTS AND DISCUSSION

3.1 The Ferroelectric Behavior

To characterize the proposed NCFET model, it is important to first acknowledge the behavior of the ferroelectric based on its parameters' variation. There are four ferroelectric parameters which are the electric field (E_c), permittivity (*esf*), spontaneous polarization (P_S) and remnant polarization (P_r). Figures 6-9 show the capacitance and polarization vs gate bias with varied *esf*, P_S, P_r and E_c, respectively.

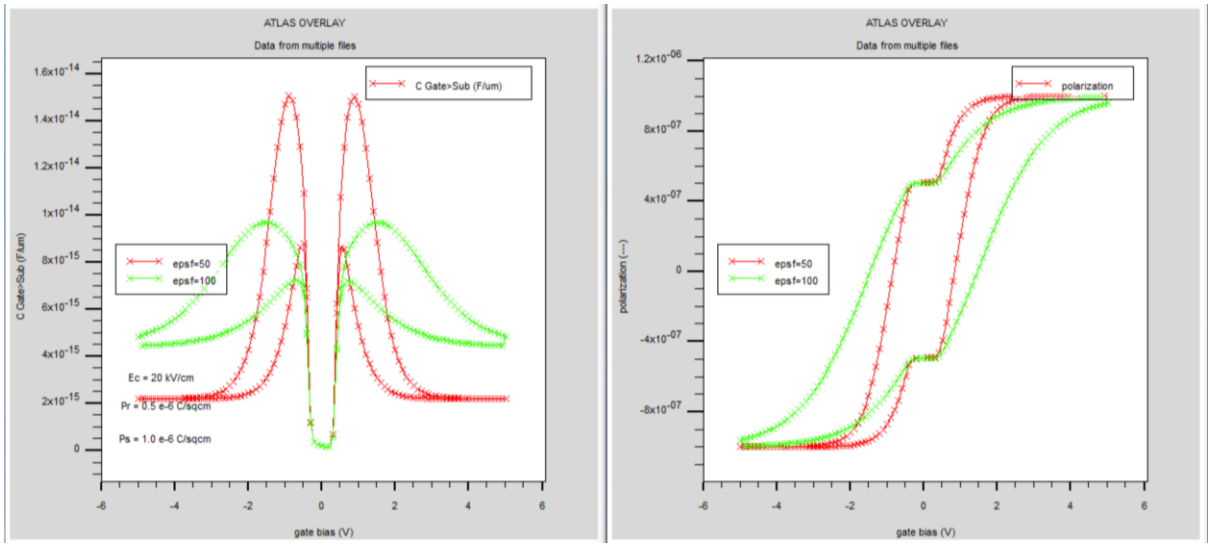

Fig. 6. The capacitance and polarization vs gate bias for *esf* = 50 and *esf* = 100

Figure 6 shows the capacitance and the ferroelectric polarization curve when the *esf* parameter is varied at 50 and 100, while other parameters are made constant (P_r = 0.5μC/cm^2, P_S = 1μC/cm^2, E_c = 20 kV/cm). The figure shows that the 100-*esf* ferroelectric exhibits higher capacitance and thinner hysteresis loop as compared to that of 50-*esf* ferroelectric.

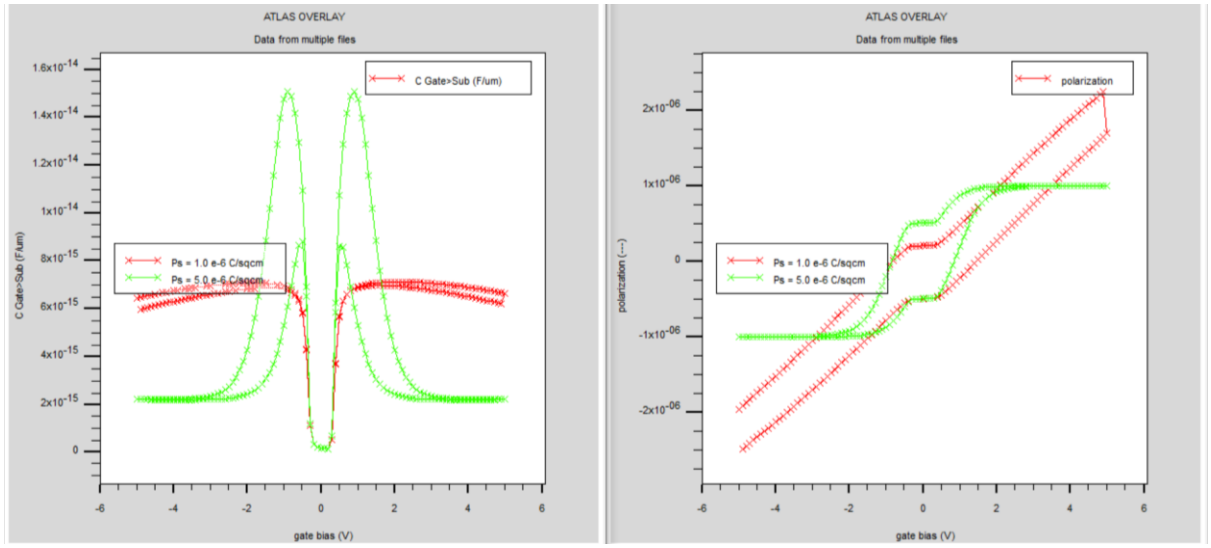

Fig. 7. The capacitance and polarization vs gate bias for P_S = 1μC/cm^2 and P_S = 5μC/cm^2

Figure 7vshows the capacitance and the polarization curve of the ferroelectric when the P_S parameter is varied

at 1μC/cm^2 and 5μC/cm^2, while other parameters are made constant (esf = 50, P_r= 1μC/cm^2, E_c = 20 kV/cm). From the figure, it can be concluded that as the P_S parameter increases, the ferroelectric capacitance also increases, and the hysteresis loop becomes smaller.

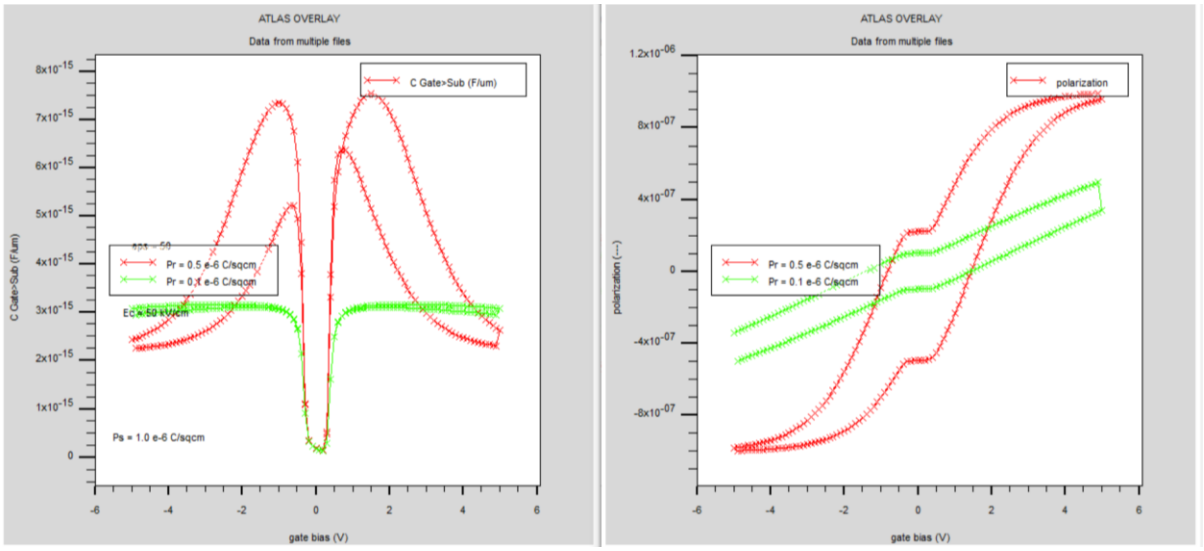

Fig. 8. The capacitance and polarization vs gate bias for P_r =0.5μC/cm^2 and P_r =0.1μC/cm^2

Figure 8 shows the capacitance and the polarization curve of the ferroelectric when the P_r parameter is varied at 0.5μC/cm^2 and 0.1μC/cm^2, while other parameters are made constant (esf= 50, P_S = 1μC/cm^2, E_c = 50 kV/cm). From the figure, it is observed that each different P_r yields a very different shape of the hysteresis loop and the 0.5μC/cm^2-P_r ferroelectric exhibits much higher capacitance as compared to the 0.1μC/cm^2-P_r ferroelectric.

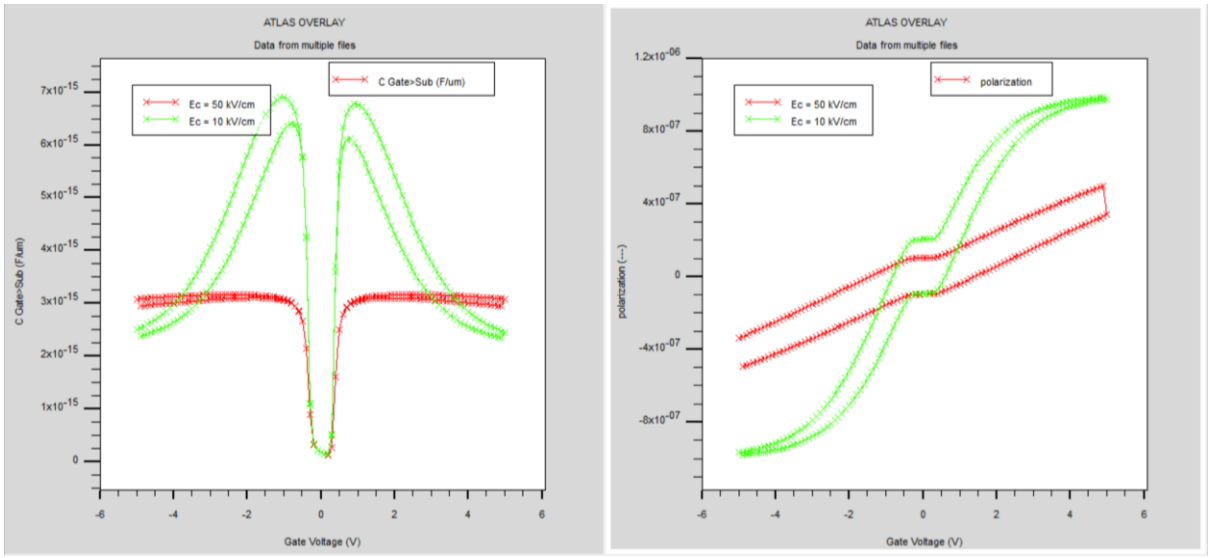

Fig. 9. The capacitance and polarization vs gate bias for E_c = 50 kV/cm and E_c=10 kV/cm

Figure 9 shows the capacitance and the polarization curve of the ferroelectric when the E_c parameter is varied at 50 kV/cm and 10 kV/cm, while other parameters are made constant (esf= 50, P_S = 1μC/cm^2, P_r= 0.1μC/cm^2). From the figure, it is found that the 50 kV/cm-E_c ferroelectric produces a thin hysteresis loop and high capacitance.

In short, the ferroelectric parameters are affecting the capacitance and polarization behavior of the ferroelectric material. Therefore, it is better to choose suitable ferroelectric parameters to achieve a better capacitance matching between the ferroelectric and dielectric capacitor.

3.2 The NCFET Structure for TCAD Simulation

Figure 10 shows the structure of the proposed NCFET compared to MOSFET. The MOSFET consists of two layers, which are the substrate and one dielectric layer, as shown in Figure 4.6a, while the NCFET consists of 4 layers as shown in Figure 4.6b. Table 4.1 lists the NCFET parameters.

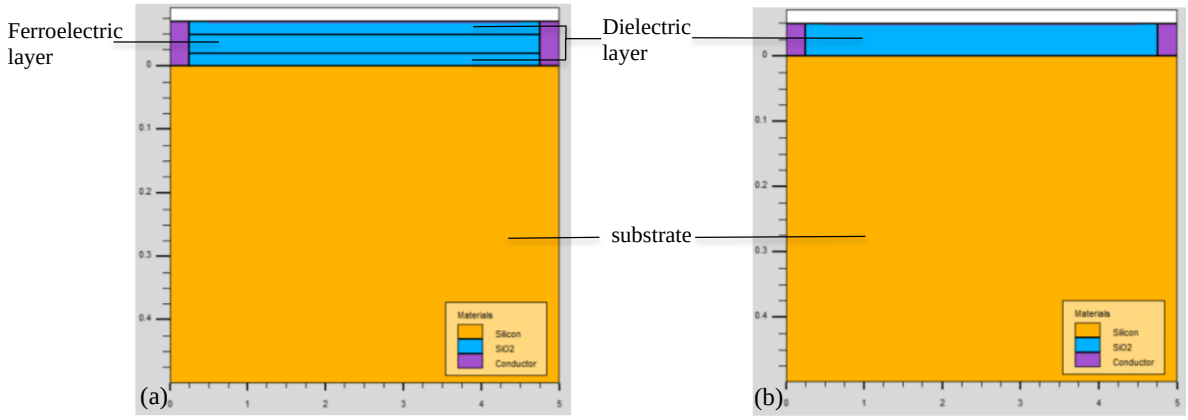

Fig. 10. The proposed structure of (a) NCFET and (b) MOSFET.

Table 1. The proposed NCFET and MOSFET parameters.

Parameter (unit)	**NCFET**
p-well doping concentration (cm^{-3})	$1x10^{19}$
Source-drain doping concentration (cm^{-3})	$1x10^{19}$
Substrate doping concentration (cm^{-3})	$3x10^{16}$
Dimension (µm x µm)	5x5
Gate length, L_g (nm)	4.5
Dielectric material	SiO_2
Ferroelectric material	E_c=1.2 MV/cm Pr=12.5e µC/cm^2 P_S=13.24 µC/cm^2 esf=35.5
Dielectric material	SiO_2
Dielectric thickness (nm)	0.02

As can be seen from Table 1, the chosen ferroelectric parameters are E_c=1.2MV/cm, P_r=12.5e µC/cm^2, P_S=13.24 µC/cm^2 and esf=35.5 for our NCFET model. On top of that, both devices' gate length is set to be 4.5nm to avoid any short-channel effect [12].

3.1.1 The Effect of Ferroelectric Thickness on the NCFET Performance

For this set of experiments, the ferroelectric layer's thickness is varied while all other parameters are made fixed, including the source-drain doping concentration of $1x10^{19}cm^{-3}$. The NCFET structures with the different ferroelectric thickness of 5nm, 10nm, 20nm and 30nm, and their I-V characteristics are depicted in Figure 11,12,13 and 14, respectively.

For all the I_D vs V_{DS} plot depicted in this project, there are three different applied gate voltages which are 1.1V, 2.2V and 3.3V and their curves are shown by the red, green, and blue curve, respectively. The drain voltage is then supplied until 5.5V with the step of 0.3V. Next, for the I_D vs V_g plot, the drain voltage is biased with 0.025V and the gate voltage is ramped from 0 to 1V with the step of 0.1V.

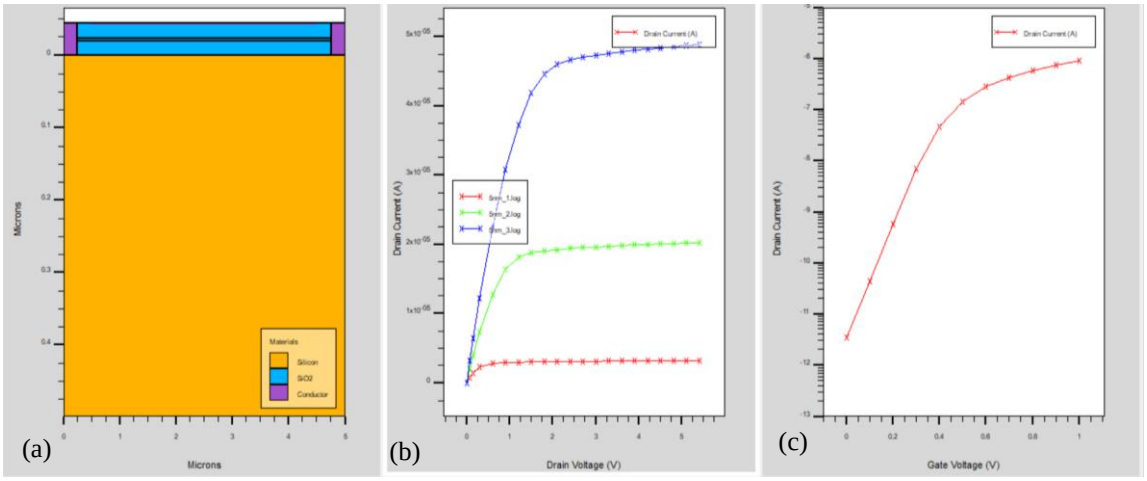

Fig. 11. Variation of drain current, I_D versus (b) Drain voltage, V_{DS} (c) Gate voltage, V_g of **5** nm thick ferro NCFET.

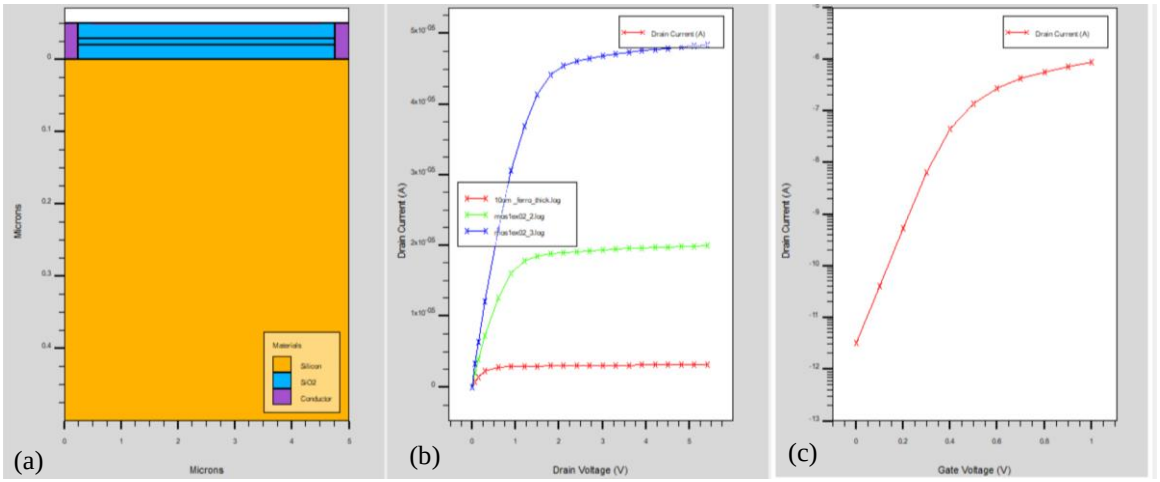

Fig. 12. Variation of drain current, I_D versus (b) Drain voltage, V_{DS} (c) Gate voltage, V_g of 10 nm-thick ferro NCFET.

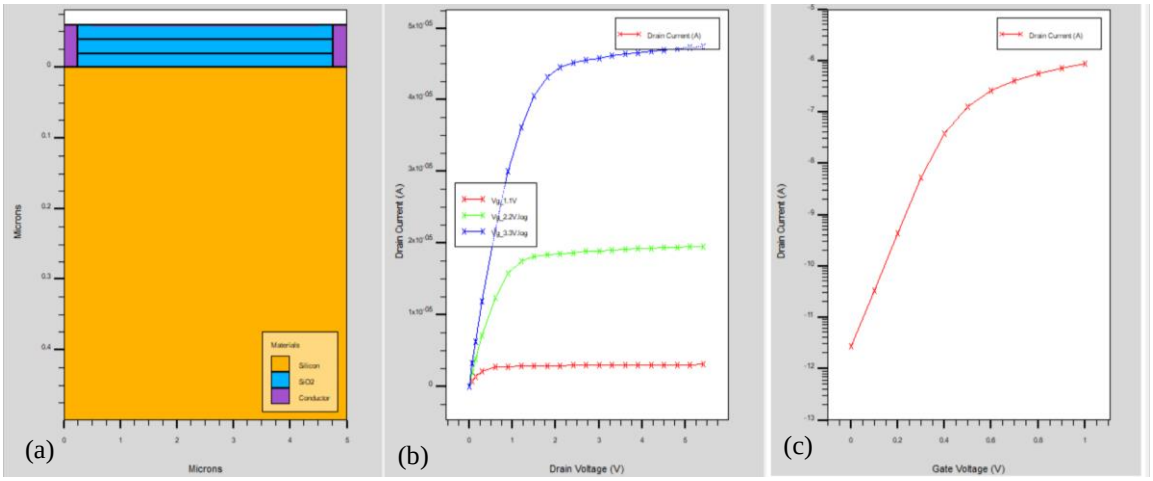

Fig. 13. Variation of drain current, I_D versus (b) Drain voltage, V_{DS} (c) Gate voltage, V_g of 20 nm-thick ferro NCFET.

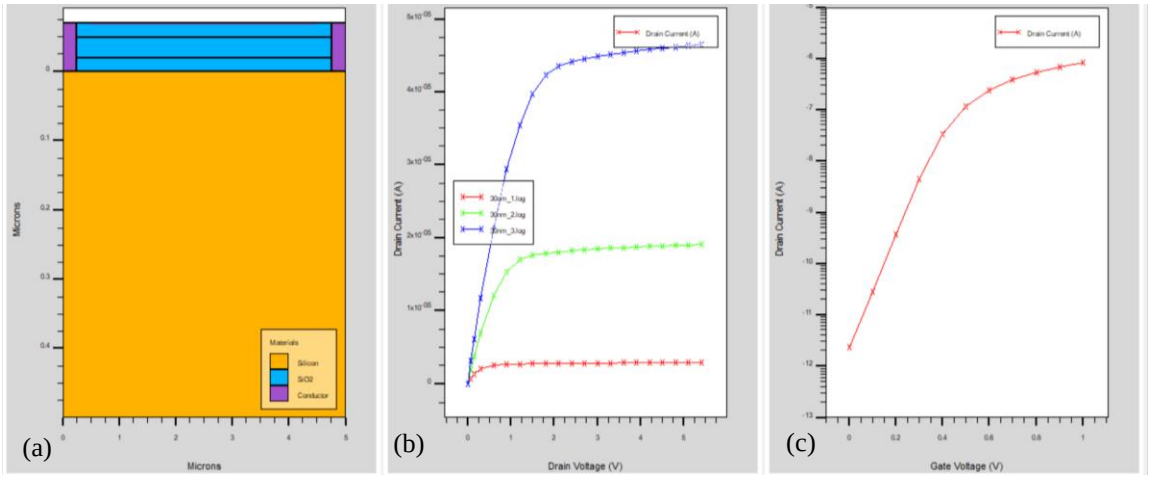

Fig. 14. Variation of drain current, I_D versus (b) Drain voltage, V_{DS} (c) Gate voltage, V_g of 30nm-thick Ferro NCFET.

From the results shown in Figure 11 until Figure 14, it shows that all the NCFET with different ferroelectric thickness are following the MOSFET I-V characteristic. Next, the behaviors of the NCFET in terms of peak current, saturation slope, saturation current and subthreshold slope are summarized in Table 2.

Table 2: The NCFET electrical behaviors with different ferroelectric thickness.

Ferroelectric thickness (nm)	**Peak Current (mA)**	**Saturation Slope (µA/V)**	**Subthreshold slope with bias drain voltage = 0.025 V (mV/dec)**	**Voltage Gate (V)**	**Saturation Current (mA)**
5	0.04889	0.4615	89.102	1.1	0.003212
				2.2	0.020251
				3.3	0.048877
10	0.04837	0.4623	89.3754	1.1	0.003147
				2.2	0.02
				3.3	0.048364
20	0.04742	0.467	89.9125	1.1	0.003031
				2.2	0.019542
				3.3	0.047424
30	0.0465	0.47366	90.4744	1.1	0.002917
				2.2	0.019094
				3.3	0.0465

Figure 15 depicts the relationship between the peak current and the saturation slope with the ferroelectric thickness. From the figure, it is found that as the ferroelectric thickness increases, the peak current decreases, whereas the saturation slope is increasing with the ferroelectric thickness, although there is not much difference between the slope values.

Figure 16 shows the relationship between the subthreshold slope and ferroelectric thickness. The plot shows that the subthreshold slope is directly proportional to the ferroelectric thickness. In terms of subthreshold slope, the best performance is achieved by the 5nm-thick ferroelectric NCFET as it achieves the steepest slope of 89.10mV/dec. As in equation (5), when the ferroelectric thickness (T_{FE}) increases, the ferroelectric capacitance (C_{FE}) decreases, which makes it closely match the C_{MOS}. The enhanced matching between the C_{MOS} and the C_{FE}($|C_{FE}|-C_{MOS}>0$) then increases the voltage amplification factor, A_G. The voltage amplification factor and the subthreshold slope have a negative correlation, which implies that the higher the ferroelectric thickness, the steeper the subthreshold slope.

$$C_{FE} = \frac{dQ}{dV_{FE}} = \frac{1}{2\alpha T_{FE}} = \frac{2}{3\sqrt{3}} \frac{P_r}{E_c T_{FE}} \quad (5)$$

$$A_G = \frac{|C_{FE}|}{|C_{FE}| - C_{MOS}} \quad (6)$$

$$SS = 60\ x\ \left(1 + \frac{C_{dm}}{C_{ox}}\right) x \frac{1}{A_G} \quad (7)$$

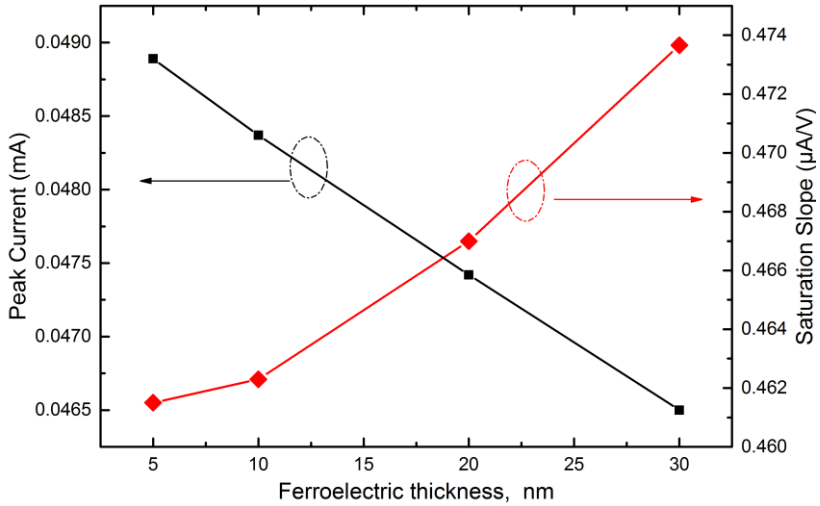

Fig. 15. Peak current and the saturation slope vurses ferroelectric thickness

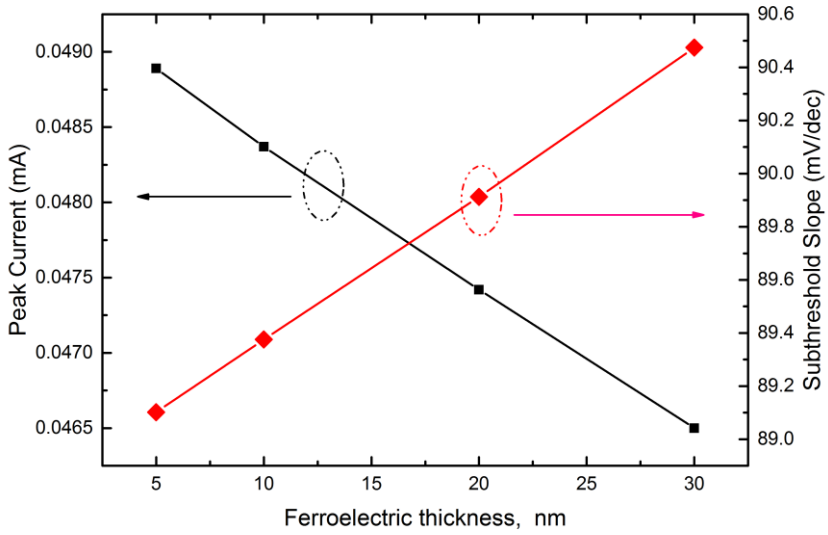

Fig. 16. Subthreshold slope versus ferroelectric thickness.

Figure 17 shows the relationship between the peak current and the subthreshold slope with the source-drain doping concentration. The figure shows that the peak current is directly proportional and the subthreshold slope is inversely proportional to the source-drain doping concentration. The higher the doping concentration, the greater the depletion capacitance (C_{dm}), the greater the increases in C_{dm}/ C_{FE} as compared to the C_{dm} / C_{ox}, and thus, the steeper the subthreshold slope. However, noticed that the subthreshold slope, SS is not less than 60 mV/dec as it supposed to be as according to equation (8), the absence of proper fabrication processes and other ignored variables.

$$SS = 60\ x\ (1 + \frac{C_{dm}}{C_{ox}} - \frac{C_{dm}}{|C_{FE}|}) \quad (8)$$

Where C_{dm} = Depletion capacitance, C_{ox} = Gate oxide capacitance

Therefore, it is found that by increasing the source-drain doping concentration in the proposed NCFET model, the subthreshold slope can be made steeper.

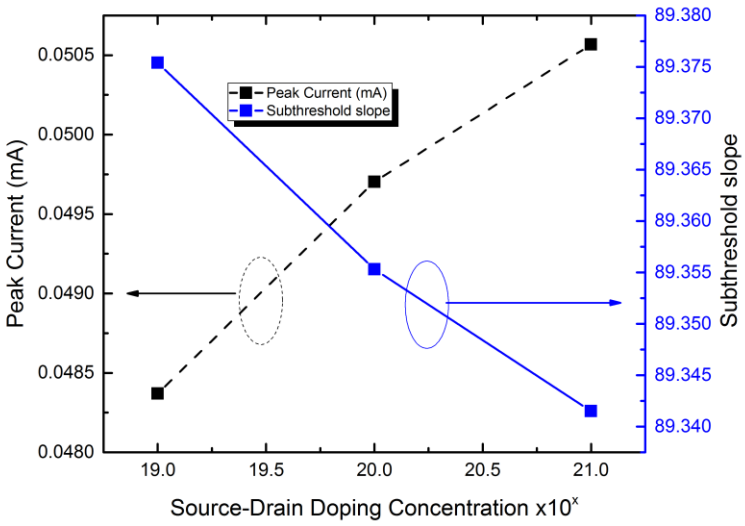

Fig. 17. Subthreshold slope vurses source-drain doping concentration.

4. CONCLUSION

The effects of ferroelectric parameters (electric field (E_c), permittivity (esf), spontaneous polarization (P_S) and remnant polarization (P_r)) are studied on its capacitance and polarization behaviors. Next, the structure and parameters of the proposed NCFET is presented. The effects of the ferroelectric thickness and source-drain doping concentration on the proposed NCFET and MOSFET behavior are demonstrated. It is proved that the NCFET has better performance as it achieved a steeper subthreshold slope.

The results show that as the ferroelectric thickness increases, the peak current and the saturation current are decreasing while the saturation slope and subthreshold slope are increasing. Next, in terms of the source-drain doping concentration, the peak current, saturation current, and saturation slope are increasing with the source-drain doping concentration, while the subthreshold slope is inversely proportional to the doping concentration.

ACKNOWLEDGEMENT

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Optimization of Combined Thermal Power Plant and Performance Analysis using Matlab/Simulink using Real Data: Kuwait as a Case Study

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Abstract— To increase the overall plant efficiency, the Combined cycle power plant (CCPP), which is a combination of the Gas turbine (Brayton cycle) and steam turbine (Rankine cycle), is a highly efficient system for electricity generation. In this paper, optimization and performance simulation analysis of Subiyah Combined Thermal Power Plant using real operating data is performed. The model is developed using MATLAB software. The main factors in the top and bottom cycles of the combined cycle are investigated and discussed. The simulation results demonstrate the exhaust of the Gas turbine reached up to 600°C. The net-power output based on the performance model using MATLAB (Simulink) is greater than the station's current real output by 20.5%. The overall thermal efficiency of the power plant is also raised from 50.5% to 55.2%.

Keywords: *electricity generation, Combined cycle power plant (CCPP), Gas turbine (Brayton cycle) and steam turbine (Rankine cycle).*

1. INTRODUCTION

The combination of the gas turbine cycle and the steam turbine cycle is one of the most promising technologies in power generation. The main concept of such cycles is based on supplying the heat to the gas cycle. Therefore, it uses the same components of the above cycles to generate more efficient power output. The heat from the gas turbine exhaust powers the steam cycle. This cycle works between the gas turbine's high temperature and the low temperature of steam turbine heat rejection. Therefore, the performance of the combined power plant is better than the performance of both plants individually. It is also suitable to run facilities like those run by the steam turbine or the gas turbine power plants. For example, it successfully provides a power output that suits the middle-sized peak facilities like a gas turbine and extensive baseload facilities like a steam turbine. Using natural gas to power combined cycle power plants im- proves its efficiency and consumes less time and costs than coal-fired power plants.

The concept of a combined cycle power plant is based on increasing the heat recovery from the same heat input to generate extra power. The combined cycles' advantage is guaranteed by using the appropriate working fluid and its physical states to attain the best heat transfer between cycles. Experimentally, the best successful configuration was proved to be between the gas turbine Brayton cycle and the steam turbine Ranking cycle. The

processes involved in this combination are illustrated thermodynamically by Fig. 1. Therefore, to enhance their efficiency and reduce energy depletion and greenhouse gas emissions, a major industry initiative and focused studies related to the gas turbine cycle have recently emerged [1–4]. Several scientists have tested the combination of regenerative cycle gas turbines [2–5]. An advanced gas turbine with a regenerator was considered by [6] to recover power and increase both combined cycle performance and electrical efficiency.

A peak power output from the steam turbines reached 100MW in the 1930s. This amount was boosted to 1000MW in the 1960s and to 1300 MW in the 1970s. In the 1960s, the gas turbine exhaust gases were used to power the steam turbine engine to generate the combined cycle power plant, which had higher performance.

The temperature of the waste exhaust gas from the gas turbine decreases as it flows into the superheater, evaporator, and economizer heat recovery steam generator (HRSG). The HRSG then provides the steam for the steam turbine to produce electricity. The steam turbine's surplus condensate will be transferred to a condenser in the steam turbine, where cooling water moves waste heat to the cooling tower. Feedwater is the supply from a condenser in the final stage, then sucked by the feedwater pump and sent to the steam generator for heat recovery and so on [7]. Compared to the gas turbine-based plant or steam turbine-based plants, these have higher thermal efficiency in isolation; the gas/steam combined cycle power plant's output depends on the topping and bottoming cycle output. If the turbine inlet temperature (TIT) can be increased, gas turbines give high specific work performance. As the efficiency of the heat recovery steam generator (HRSG) and the steam turbine improved due to the rise of TIT, that also cause the improvement of the combined cycle output [8]. The HRSG is a three-component heat exchanger, namely the economizer, the evaporator, and the superheater, and can be built with standard single-pressure or multi-pressure setups, with or without additional firing. In a study on the optimization of the Maputo power plant, it was found that a steam turbine's most critical design parameter is the steam data that includes the input pressure and temperature of the mass flow and steam turbine and the condenser pressure [9].

In this paper, a Combined cycle power plant (CCPP) is utilized for performance analysis study. This paper aims to optimize and perform simulation analysis of the Subiyah Combined Thermal Power Plant using real operating data. The model is developed using MATLAB software.

2. SYSTEM ARCHITECTURE AND MODELING

Subiyah Thermal Power Plant produces 2GW (2000MW) gas-fired power station comprises four combined-cycle power blocks. This plant was converted into combined-cycle operations with a total generating capacity of 2GW in phase two completed in July 2012.

The design and simulation in this work will be for one block out of the four available in the station. Based on the data, the output of this unit is around 270MW with 50% of efficiency. The Combined Cycle Power Plant's major components are Gas turbine, Heat recovery, steam generator, Steam turbine, and Balance of plant systems. The other components are Heat exchangers, Water pumps, Condensers, Electrical Generators.

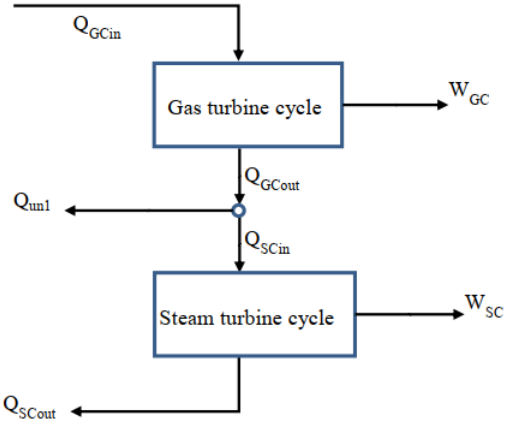

Fig 1. The combination between a gas turbine and a steam turbine cycles

Table 1. Data for Main Parameters (Combined cycled)

Parameter	Value	Unit
Inlet Temp. of the Air (Ambient temp)	34	oC
Inlet Pressure	1	Bar
Pressure ratio	10.1	-
Specific heat capacity of Air	1.005	kJ/kgK
Compressor efficiency	80% (0.8)	-
Intercooling efficiency	90% (0.9)	-
Isentropic index	1.4	-
Specific heat capacity of gas	1.15	kJ/kgK
Max. Gas Temp. for the turbine	1200	oC
Mechanical efficiency	95% (0.95)	-
Turbine isentropic efficiency	85% (0.85)	-
Boiler heat exchanger effectiveness	0.85	-
Total Power (1 unit)	500	Megawatt
Turbine efficiency	0.85	-

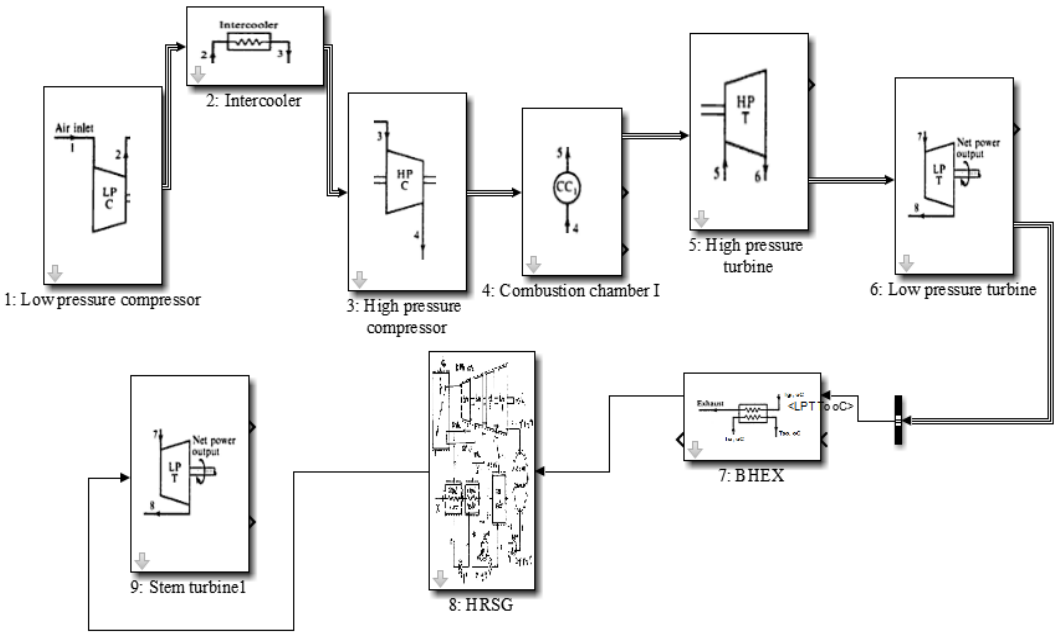

Figure 2. Full diagram (Gas-turbine with intercooling, reheat, and regeneration)

Figure 2 shows the complete diagram of the project (1 unit); a combined-cycle power plant uses both a gas and a steam turbine together to produce up to 50 percent more electricity from the same fuel than a traditional simple-cycle plant. The gas turbine's waste heat is routed to the nearby steam turbine, which generates extra power.

A hand measurement analysis of this configuration gas turbine cycle involving examining properties at ten different points is particularly tedious when compressor and turbine irreversibility and pressure losses are considered. The MATLAB software is used to design the model, run the simulations to study the performance analysis, and compare the results with the available currently in the power plants.

3. RESULTS AND DISCUSSION

In this section, the performances of the combined cycle thermal power plant are presented. The performance analysis and optimization of combined cycle thermal power plant two simulations have been done in this work.

3.1 Steady-state mode and Dynamic mode

The first part will be in a steady state. Stop time is 0. The unit with steady-state mode (Temp is 1200°C). The second part of the study is in the Dynamic state (Gas temp) is in Dynamic mode between (400°C to 1200°C): The results of main parameters such as (Heat and Heat add in each cycle, efficiency in the top and bottom cycles, mass flow rate, and temperature are analyzed. The energy in the top cycle will increase with a certain time during the increasing temperature from 400°C to 1200°C in the combustion chamber, as shown in Figure 2.

Figure 3 and Figure 4 show the gas turbine cycle's mass flow rate and efficiency, respectively. The change of the heat in the heat recovery steam generator with respect to time is shown in figure 5, which is the total heat transfer rate for boiler/superheater/ reheater.

The top cycle temperature reached up to 1200°C. However, the waste heat or the exhaust gas Temperature from the gas turbine reaches up to 634°C as shown in figure 6. which is enough to use in several applications. In this design, the exhaust temperature will be reused in the steam section to reheat the water as we mentioned earlier.

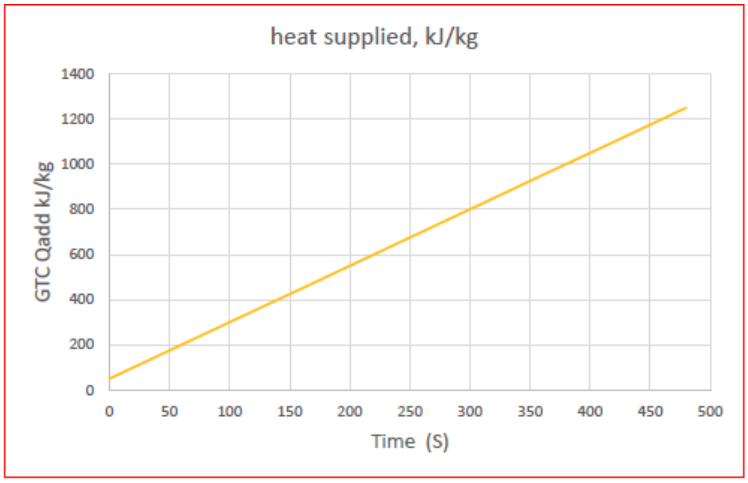

Figure 3. Energy supplied to the top cycle (Gas turbine Cycle, GTC)

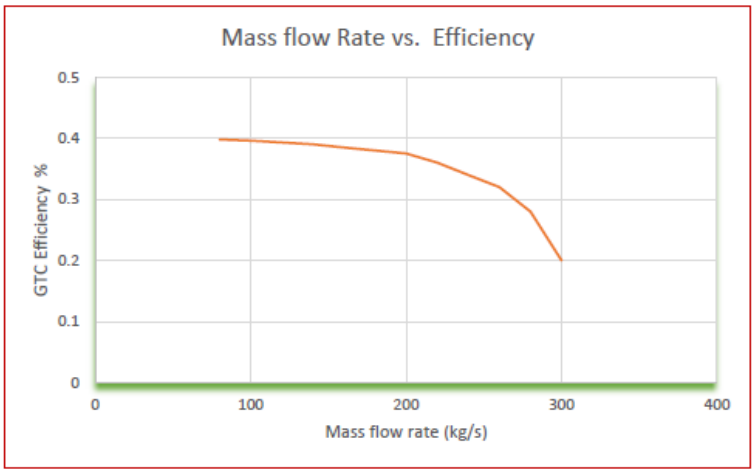

Figure 4. Cycle mass flow rate Vs. Gas turbine cycle efficiency

Table 2: Results (Steady-state mode, Temp = 1200°C)

Parameter	Value	Unit
LPC Outlet Temp.	488.3	K
LPC Outlet Pressure	3	Bar
LPC Outlet enthalpy	490.6	kJ/kg
Outlet cooling air Temp.	470.6	K
Intercooler Outlet enthalpy	328.2	kJ/kg
HPC Outlet Temp.	519	K
HPC Outlet Pressure	15	Bar
HPC Outlet enthalpy	521.9	kJ/kg
CC Outlet Temp.	1470	K
CC Outlet Pressure	15	Bar
CC Outlet enthalpy	1696	kJ/kg
Q_{add} (Heat supplied to the cycle)	1556.9	kJ/kg
HPT Outlet Temp.	1113	°C
HPT Outlet Pressure	4.3	Bar
HPT Outlet enthalpy	1310	kJ/kg
Gas turbine cycle efficiency	0.37	49%
Top steam Temp.	841.1	°C
Exhaust Gas turbine Temp.	634.3	°C
Steam Turbine stages energy	1276	kJ/kg
Net steam turbine Energy	1255	kJ/kg
Pump Energy	20.98	kJ/kg
Total Mass flow rate	664.8	Kg/s
Thermal efficiency	0.446	44.6%

Figure 5. Top cycle efficiency (GTC efficiency %)

Turbine components will withstand certain temperatures otherwise will damage if we increase the temperature more than the limit. The efficiency reaches up to 39.80% in the top cycle while the temperature was around 1200°C. However, the overall efficiency shown in figure 7, the graph reaches up to 55.20%, when the

TIT is around 1200°C with a pressure ratio of 15. The figure shows the relationship between Gas turbine efficiency and the overall thermal efficiency of the power plant. Table 3 shows the comparison between the current output and efficiency of the Subiyah station and the results from the simulations.

Using MATLAB (Simulink) based on real operating data from the station is shown in table 1. Based on these results, there are some losses due to less gas turbine maintenance or lifetime.

Table 3. Comparison between the actual and real output

Parameters	Real Data	Simulations (MATLAB)
GT Efficiency %	34%	39.80%
Overall thermal Efficiency %	50.50%	55.2%
GT output power (MW)	160	200
ST output power (MW)	110	140
Net Power output (MW)	270	340

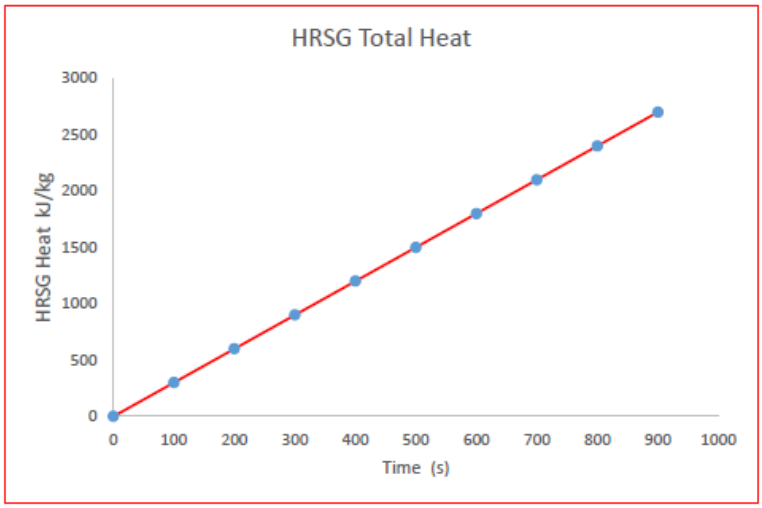

Figure 6. HRSG Total Heat

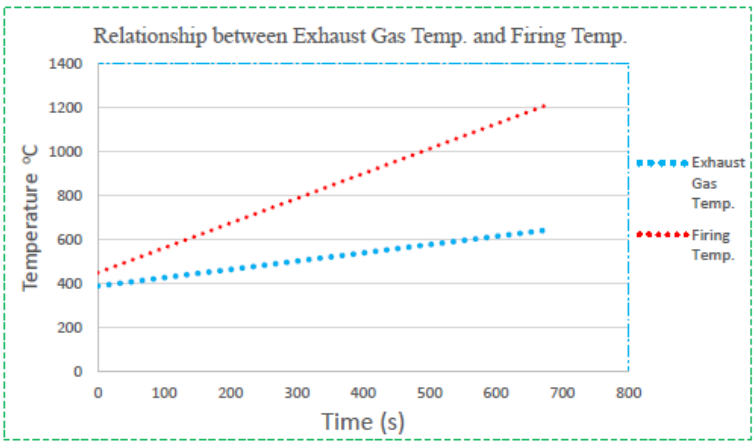

Figure 7. Exhaust Gas Temp vs. Firing Temp

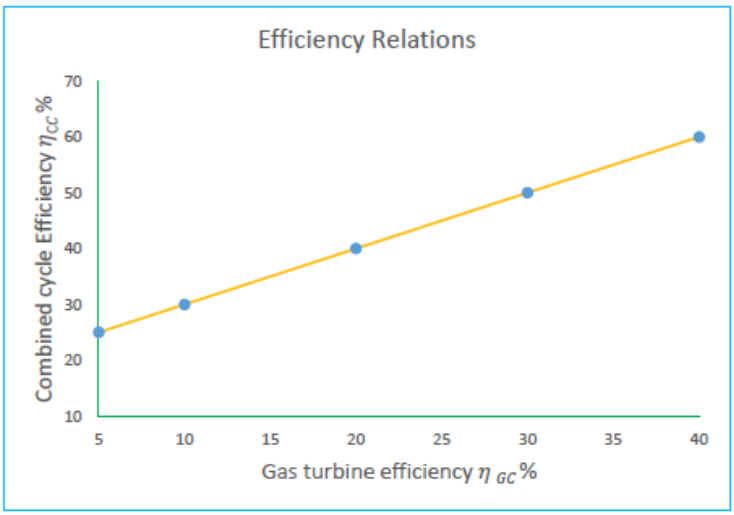

Figure 8. Overall efficiency vs. Pressure ratio in Combine cycle

Several factors increase the power output, such as increasing the turbine inlet temperature and supporting the station with the reheated system. To increase the temperature in the heat recovery steam generator (HRSG), or implementing the gas turbine's reheated configuration, is to increase both the output power and the exhaust temperature.

4. CONCLUSION

The performance modeling and analysis and optimizations of single and combined cycled in Sabiyah Thermal Power Plant are studied. Meanwhile, the climate policy and air pollution need to be taken into consideration. To optimize them and to get closer to the limit of what the material can withstand. It is required to improve the cycle's performance and reduce both the natural gas used for driving the cycle and the CO2 emissions.

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