SAIIE29 Proceedings, 24th – 26th of October 2018, Spier, Stellenbosch, South Africa © 2018 SAIIE

SHAPING THE FUTURE OF RESIDENTIAL HOUSING PROJECTS – BREAKTHROUGH IN MINDSET AND TECHNOLOGY

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ABSTRACT

The objective of this paper is to illustrate how the application of Fourth Industrial Revolution principles and technology during the construction and management of a residential housing development can add value and contribute to the well-being of property owners, managers and residents. In the pursuit of this objective the methodologies involved in the development of formal theory seemed most appropriate to achieve these objectives. Building theory from case studies is a research strategy that involves using one or more cases to create theoretical constructs, from case-based, empirical evidence. In the paper the nature and extent of the South African residential housing landscape is firstly described. Some of the challenges inherent to the development and management of large scale residential developments are then discussed. A solutions framework to address some of these challenges consisting of six core elements is then presented. These core elements are a Centrailised Hot Water System powered by a PV plant, smart metering of three utilities (electricity, cold water and hot water), an automated shut-off mechanism for hot water, an Integrated Utilities Management Platform, an optimized utilities payment protocol and a Smart Payment Application. The paper concludes with an evaluation of the impact of the framework measured against the three core design objectives namely increased control, optimized operational efficiency and sustainability.

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1. INTRODUCTION AND BACKGROUND

"The world is on the brink of a technological revolution that will fundamentally alter the way people live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before. It is not yet clear just how it will unfold, but one thing is clear -- the response to it must be integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academia and civil society." [1]

Klaus Schwab, the Founder and Executive Chairman, of the World Economic Forum made the above statement in a paper presented at for the world economic summit at Davos in 2016, profiling what he calls The Fourth Industrial Revolution.

The world is confronted with many challenges that could impact the well-being and happiness of society. Among the most severe are rapid urbanization, climate change and resource scarcity. According to the World Economic Forum [2] around the world, 200,000 people a day are migrating to urban areas, where they need healthy, affordable, sustainable housing and infrastructure. However, the buildings and infrastructure assets the industry constructs account for a substantial portion of global greenhouse gas emissions, which are a major cause of climate change. On top of that, the industry is the largest consumer of raw materials, further depleting scarce resources.

The Infrastructure and Urban Development (IU) industry is important in the shaping of a desirable future for our planet. The sector plays a vital role in creating value for society by designing innovative human- and social-centric solutions. The IU industry lies at the heart of the global economy, directly affecting the quality of our lives and the well-being of society. The industry must, therefore, react quickly and with appropriate action to changing conditions and opportunities for new business to provide society with sustainable, affordable assets that fulfil human needs.

Digital technologies have launched the Fourth Industrial Revolution (FIR), transforming entire industries. The FIR will have a significant impact on the world of commerce and work specifically. In the future fewer commercial, office and public assets will be required, because so much happens virtually and because more workplaces and other spaces will be shared. In an automated world and against the backdrop of large scale urbanization the demand for residential and recreational buildings will however increase significantly. In an economy that primarily runs on automation, people spend more time at home or pursuing leisure activities, increasing the demand for residential assets. More leisure time increases the need for recreational structures and facilities, including swimming pools, fitness centers, theatres and arenas, and large assets such as stadiums and amusement parks.

However, the Infrastructure and Urban Development industry (IU) has been slow to adopt and did not kept up with recent FIR developments. Most companies in the industry's many sectors still use primarily manual methods, offer traditional products and services and operate according to established practices and business models [2]. The IU industry can no longer afford to stand still. Global megatrends such as climate change, resource scarcity, demographic shifts, and automatization and digitalization are affecting economies, governments and society at large. Players along the IU value chain need to prepare strategically and make the right moves to thrive amid the disruptions these trends could cause [2].

1.1 Objective of this paper

The objective of this paper is to illustrate how the application of FIR technology and principles during the construction and management of a residential housing development can add value and contribute to the well-being of property owners, managers and residents.

1.2 Research design strategy and methodology

The methodologies involved in the development of "Formal theory" seemed most appropriate to achieve these objectives. During the development of the chosen methodology for this research the work done by Eisenhardt [3] was found to be extremely useful.

Building theory from case studies is a research strategy that according to Eisenhardt [3], involves using one or more cases to create theoretical constructs, propositions and/or midrange theory from case-based, empirical evidence. Theory building through case-studies is according to Eisenhardt [4] an increasingly popular and relevant research strategy that forms the basis of a disproportionately large number of influential studies.

Although the writing of the emergent theory or in this case the development of the solution framework is presented as the last step in linear process of steps, it should not be construed as such. Theory building through case studies is a highly iterative process and already starts during the justification of the need for new theory. During the research process and as observations lead to new insights it was anticipated the new literature would be explored and that the scope of research may potentially widen. With a full understanding of this risk great care was taken during both the literature review as well as the during the ultimate development of the solutions framework to not widen the scope of the study beyond the constraints of the problem statement.

1.3 Overview of the remaining sections

In this paper the following aspects will addressed:

- The FIR will be briefly defined and contextualized in Section 2;
- In Section 3 a brief overview of the South African residential housing landscape will be presented;
- In Section 4 some of the challenges inherent to the development and management of residential rental properties will be presented;
- In Section 5 the implementation context and research approach are briefly described;
- In Section 6 the solutions framework will be presented. In this section the various components as well as the interaction between these components will be discussed briefly;
- In Section 7 the impact of the framework is evaluated against three core design objectives; and
- In Section 8 a number of concluding remarks will be presented.

2. THE FOURTH INDUSTRIAL REVOLUTION – THEORETICAL CONSIDERATIONS

According Darth and Horch [5], to the first three industrial revolutions spanned almost 200 years. First, mechanical looms driven by steam engines in the 1780s started a significant change. Fabric production left private homes in favour of central factories, followed by an extreme increase in productivity. The second industrial revolution began about 100 years later in the slaughterhouses in Cincinnati, Ohio, and found its climax with the production of the Ford Model T in the United States. The development of continuous production lines based on both division of labour and the introduction of conveyor belts resulted in another productivity explosion. Third, in 1969, Modicon presented the first programmable logic controller that enabled digital programming of automation systems. The programming paradigm still governs today's modern automation system engineering and leads to highly flexible and efficient automation systems.

It is according to these authors remarkable that the Fourth Industrial Revolution (FIR) was announced a priori. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres, collectively referred to cyber physical systems (CPS) [5]. It is marked by emerging technology breakthroughs in a number of fields, including robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, the Internet of Things, the Industrial Internet of Things, fifth generation wireless technologies (5G), additive manufacturing/3D printing and fully autonomous vehicles. Digital technologies have launched the Fourth Industrial Revolution (FIR), transforming entire industries. The FIR will have a significant impact on the world of commerce and work specifically.

However, the Infrastructure and Urban Development industry (IU) has been slow to adopt and did not kept up with recent FIR developments. Most companies in the industry's many sectors still use primarily manual methods, offer traditional products and services and operate according to established practices and business models [2]. Players along the IU value chain need to prepare strategically and make the right moves to thrive amid the disruptions these trends could cause [2].

In the next section a brief overview of the some of the current and future South African housing realities will be presented.

3. THE SOUTH AFRICAN RESIDENTAIL HOUSING LANDSCAPE

The ANC, after coming to power in April 1994, promised that a democratic state would act to steer the mixed economy down a new economic growth path through various macro-economic policies. The first major attempt at creating a policy framework was a document called the Reconstruction and Development Programme (RDP). The RDP was the political manifesto of the ANC during its election campaign for the first democratic elections in South Africa in 1994 and would be used as the framework for the transition to a democratic state. Nation building and improving the living standards of all South Africans through a local government sphere is at the heart of the RDP [6].

Williams [7] is of the opinion that the RDP did achieve some of its social security objectives by establishing an extensive welfare system, helping the aged, disabled and others who are unable to meet their basic needs. However, social welfare was not the main target of the RDP but rather a focus on housing, with the goal of building more than one million houses in five years, and pro- viding water and electricity to households.

Subsequent to the RDP the ANC led government has developed no less that four additional macro economic frameworks. These include:

- Growth, Employment and Re-distribution (GEAR) -- 1996
- Accelerated and Shared Growth Initiative for South Africa (ASGISA) – 2005
- New Growth Path (NGP) -- 2010
- National Development Plan (NDP) -- 2012

Each one of these macro economic frameworks did make a contribution to creating a better life for all South Africans, but according to Ansari [8], the ANC government has largely failed to deliver on the two decades of promises of economic redistribution and industrialization. A consequence of expectations, created by these policies and unmet thus far, are the waves of service delivery protests across South Africa. Service delivery protests mostly stem from the lack of access to basic services, including access to sanitation, water, refuse removal, electricity and basic housing.

3.1 Important housing statistics

Housing is thus one of the major challenges the South African government has to overcome. According to Stats SA [6] there were 51.8 million people living in 14.5 million households in 2011 in South Africa. The average household thus consisted of 3,57 individuals in 2011. Research done by Stats SA [3] indicates that the South African population will grow to 70 million people by 2030. 70% of these people will be urbanized. In the period 2001 to 2011 the number of household grew by 2,6% per annum, while the population grew by 1,5%. The increase in the proportion of households that comprise of one person is driving the trend in declining household sizes. During the 2006 census there were only 16% of households that comprised on a single person, while the 2011 census found that 27% of households comprised on a single person. These demographic realities are summurised in Table 3.1

The department of human settlements [6], identifies four broad housing categories, Formal Dwelling; Traditional Dwelling; Shack not in backyard and Shack in backyard. Table 2.2 illustrates the changes in distribution of households per housing category in the period 2001 to 2018.

Table 3.1: Key South African demographic realities

	2001	2011	2018	2030
Total Population	44,9 mil	51,8 mil	55,9 mil	70 mil
Average size of household	3,57	3,57	3,57	3,57
Total number of households	12,5 mil	14,5 mil	15,6 mil	19,6 mil
Level of Urbanization	57%	62%	66%	70%
Need for Urban Houses	7,1 mil	8,9 mil	10,2 mil	13,7 mil

Table 3.2: Households per housing category

Housing category	2001	2011	2018
Formal Dwelling	64%	74%	81%
Traditional Dwelling	15%	8%	6%
Shack not in back yard	12%	9%	8%
Shack in back yard	4%	5%	5%
Total households living in informal dwellings	2 mil	2 mil	2,1 mil

Over that period 2001 to 2011 the private sector build around 660 000 new units. Although the number of households living in a formal dwelling thus increased by over 3,5 million between 2001 and 2011, there were still no less than 2 million household in 2011 living in some form of informal settlement or shack. In the period 2014 to 2018 an additional 410 000 low cost houses were build. The current Minister of Human Settlements, Nomaindia Mfeketo recently however confirmed that although some progress have been made regarding the delivery of more low cost houses the backlog of low-cost homes are still estimated to be at least 2.1 million.

Between 2001 to 2011 the proportion of South African households that rent their primary dwellings increased from 19% to 25%. In urban areas it increased from 26% in 2001 to 32% in 2011 [4]. In the next section the above statistics will be used to determine the urban housing requirements and thus the demand for urban housing over the next 12 years.

3.2 Urban housing requirements 2030

In an attempt to estimate the 2030 urban housing requirements a number of extrapolations from the statistics presented in Section 2.1 were made. For the purpose of these calculations the following assumptions were made:

- The trend regarding declining household sizes (discussed above) were not considered, and the average household size was considered to be 3,57 [9];
- The South African population will grow to 70 million by 2030 and 70% of the population or 49 000 000 people will live in urban areas;
- The implication is that there will be 13,7 million urban households in 2030;
- There are currently (2018) 10,2 mil urban households; and
- Of the 10,2 mil urbans households 2,1 million are however living in informal settlements.

An additional 3,5 million urban housing units need to be constructed just to cater for the growing urban population. An additional 2,1 million units however have to be constructed if the low-cost housing backlog are to be eradicated. The implication is thus that 5,6 million new urban homes need to be constructed over the next 12 years to cater for the ever increasing demand for urban houses. This equates to 460 000 housing units per year.

In Section 2.1 it was mentioned to no less than 32% of households rent their homes. If it is accepted that this proportion will not change over the next 12 years, a total of 4,4 million households will rent their homes by 2030. Of the 5,6 million new urban households at least 1,8 million will thus be rental homes. The implication is thus that at least 150 000 new housing units will have to be purposely build every year over the next 12 year for rental purposes.

4. INSTITUTIONAL INVESTMENT AND MANAGEMENT OF RESIDENTIAL RENTAL PROPERTIES

Investors typically has a large number of investment opportunities. Against the backdrop of the growing demand for residential rental properties a major South African Life Insurance company ABC[1]created a fund dedicated to the development and management of affordable residential rental stock. Over the past 10 year no less than 4000 rental units have been developed by the fund. These investment opportunities are however not risk free and require careful analysis and planning. The performance of the fund is measured through generally accepted financial indicators such as Yield, Net Operating Income and Asset Value Growth [10]. A detailed discussion of these measure fall outside the scope of this document.

The management of the units are outsourced to a number of dedicated property management companies. Company XYZ[2] was appointed by ABC to manage some of the rental assets on their behalf. In the next section

[1] Company ABC is a pseudo name and used to ensure confidentiality.
[2] Company XYZ is a pseudo name and used to ensure confidentiality

some of the challenges faced by XYZ during the management of the institutionally owned rental stock will be presented.

4.1 Challenges inherent to the management of a residential rental portfolio

The long term management of an institutionally owned large scale residential rental portfolio has a number of inherent challenges. These challenges are grouped together under the following headings:

4.1.1 Asset strategy and management

The Portfolio Yield is often the most important indicator for success when a Residential Rental portfolio is evaluated. Portfolio Yield is a function of a number of factors including Total Operating Cost, Average Rental Income and Total Occupancy Rates. The Asset Strategy considers all these aspects. It is thus essential to develop a realistic and achievable strategy at the outset of every project. Market conditions are however extremely volatile and strategy development has thus become an ongoing activity. It requires constant market analysis and plan iteration. This include advise on unit design, roll-out plans and rental increases and decreases.

4.1.2 Management reporting and feedback

The key to making good Asset Management decisions is access to appropriate information. Asset intensive organizations rely on asset data, information and ultimately asset knowledge as key enablers in undertaking both strategic Asset Management activities and operational Asset Management activities. There are currently no integrated rental management system that ensures both the capturing of operational and performance data, and that enables integrated and portfolio wide reporting and analysis.

4.1.3 Property marketing and tenant management

Total Occupancy Rate is a function of both growth and retention. Effective property marketing and tenant management thus requires a detailed understanding of both these aspects. Within the context of existing property– and consumer protection legislating[3], the placement of high quality and reliable tenants are critical. Unreliable and non-paying tenants quickly become a huge liability and result in huge value destruction. According to the Rental Monitor report [11],

- 69% of renters pay their rent on time;
- 11% of renters pay late but within the month;
- 5% of renters have some form of payment arrangement in place; and
- 5% of renters have outstanding rent that are never paid.

Within the context of South African Legislative framework the eviction of non-paying tenants has become extremely cumbersome. The eviction process normally takes extremely long and is very costly. The tenant management process thus requires constant interaction and communication.

4.1.4 Physical Asset Management (Facilities Management and Maintenance)

The contemporary business environment has raised the strategic importance of the Physical Asset Management (PAM) function in organizations which have significant investment in Physical Assets such as residential properties. Organizations the world over are increasingly becoming more and more capital intensive and it has been found in various studies that spending on assets and asset maintenance has been increasing steadily over the past number of decades.

The Institute for Asset Management (IAM (2011)) [12], defines Asset Management Strategy as follows:

[3] There are at least 20 statutes and Acts relating to property in South Africa. A detailed discussion of the current legislative framework governing the management of rental properties in South Africa falls outside the scope of this document. It is however important to note the suit of legislation and regulations is extremely cumbersome and complicates the management of rental portfolios significantly.

"Long term optimized approach to the management of assets, derived from, and consistent with the organizational strategic plan and the asset management policy"

Within this context PAM has become a critical support function. The definition of relevant and adaptive PAM strategies is thus critical to the long-term success of any asset owner.

4.1.5 Utilities Management

The vending and management of utilities within large residential estates are inherently complex. The ineffective management of this process not only cause huge tenant frustration, but can also result in costly under recovery.

5. THE CATALYST FOR CHANGE

Company XYZ has a very strong focus on Operational Excellence. The management team is constantly seeking ways to optimize and redefine ineffective processes. During the management of the property portfolio's under its control the challenges and inefficiencies inherent to the management of this type of asset (and briefly introduced above) become apparent.

In an attempt to address the inefficiencies the XYZ management team in collaboration with a number of stakeholders developed a solutions framework and implemented the framework during the development and management of a new residential estate – Sun Village[4]. The purpose of this solution framework was not address each one of these challenges (referred to in Section 4) but to apply Fourth Industrial Revolution technology and principles to add value and contribute to the well-being of property owners, managers and residents. It was agreed that the impact of the framework would be evaluated against the following three design objectives presented in Table 5.1:

Table 5.1: Solution framework design objectives

Design Objective	Description
Control	The extent to which the framework provide more control to all stakeholders.
Operational Efficiency	The extent to which the implementation of the framework lead to higher levels of operational efficiency.
Sustainability	The extent to which the implementation of the framework ensures higher levels of both environmental and financial sustainability.

Sun Village consist of 330 rental properties. The development consists of 18 blocks of 3 story apartments that range in size and typology. The size and unit typology is presented in Table 4.1.

Table 5.2: Size and typology of apartments at Sun Village

Typology	Number	Size
Studio	17	28m2
One Bedroom	21	36m2
Two Bedroom	257	48m2
Three Bedroom	35	56m2

This solutions framework is presented in this next section.

6. THE SOLUTION FRAMEWORK

During the design phase of the Sun Village the XYZ management team conceptualized a number of solutions to address some of the above mentioned inefficiencies. Although these solutions were initially considered to be stand-alone, close collaboration with various stakeholders enabled the management team to implement an integrated optimized operations management process. The Solutions Framework is presented in Figure 5.1.

[4] Sun Village is a pseudo name to ensure confidentially.

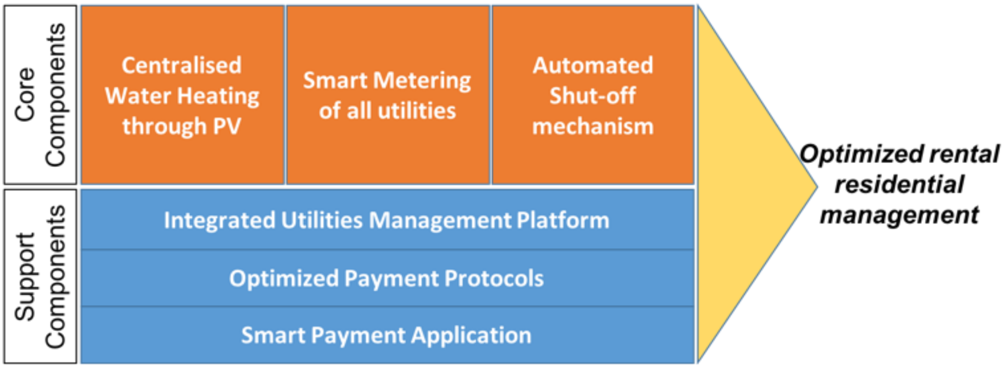

Figure 6.1: The Solutions framework

The solution consists of the following components:

- A Centralised Water Heating System (CWHS) and a Photovoltaic (PV) plant;
- Smart Metering of all utilities;
- An automated shut-off mechanism for hot water;
- An Integrated Utilities Management Platform (IUMP);
- An optimized utilities payment protocol; and
- A Smart Payment Application (SPA)

Each one of these components are briefly introduced in the next section.

6.1 A Centralised Water Heating System (CWHS) and the use of sustainable energy

In this section the focus will firstly fall on different types of water heating systems, and secondly on sustainable sources of energy. The section will conclude with a presentation of the water heating solution that was crafted for the Sun Village estate.

6.1.1 Water heating systems

Domestic hot water systems can be divided into centralised and localised. A *localised system* is one in which the water is heated locally to its needs. It may be chosen where a long distribution pipe would mean an unnecessarily long wait for hot water to be drawn off at the appliance. Traditionally most residential developments installed localised Hot Water Heating Systems (HWHS).

A *centralised system* is one in which the water is heated and possibly stored centrally within the building, supplying a system of pipework to the various draw-off points. Traditionally these systems also utilized direct electrical resistance heating elements to heat water.

6.1.2 Sustainable sources of energy

Concerns for the environment, combined with rising fuel costs, mean that more and more organizations are looking to alternative and more sustainable sources of energy to power and heat homes. The use of alternative energy source is often referred to as microgeneration. For the purpose of this document reference will only be made to three methods of alternative energy generation to power homes and more specifically to heat water.

Solar Thermal -- Solar thermal is according to Conran [13] a tried and tested technology that uses the sun's energy to heat water. Although solar thermal systems are most effective when they are installed in new houses, especially as integral building elements, they are also highly suitable for retro-fitting. Solar termal systems has become the gold standard in most affordable residential property developments within South Africa. It is however not possible to use Solar Thermal technology to heat water within a centralized water heating system. The use of Solar Thermal water heating technology thus requires the installation of one Solar Geyser per apartment or house.

Photovoltaics (PV) – Another type of solar generator is the photovoltaic cell or PV, as the name suggests converts the sun's energy into electricity. According to Chu et.al [14] PV cells, made from cilicon, are grouped to form modules, which are then arranged in panels or arrays of panels. Huge advance have taken place in this area of technology in recent years. One new development is a complete roofing system that uses PV panels in the same fashion as ordinary roof tiles. Sunlight falling on PV panels is converted electricity. The electricity is produced in Direct Current (DC), which then has to be converted to Alternating Current (AC) in an invertor. During the day (when the sun shines) the PV system generates electricity continuously, with the surplus or spare capacity flowing into the grid. Even in countries were households receive only a relatively small amount of money for the surplus energy they produce, it is still possible to make a net saving [15]. Despite the fact that South African electricity production is under severe pressure very few South African municipalities allow microgenerators of electricity to feed electricity back into the grid. A detailed discussion of the reasons for this unwillingness falls outside the scope of this document. Most PV systems in South Africa is thus run of the grid and surplus energy has to be stored in a battery that acts as the main power supply.

The use of PV in large residential developments within the South African context has been limited until recently. This is mainly due to two reason:

- The generation of electricity through PV and the demand for electricity within a residential complex is out of sync as illustrated in Figure 5.2. The yellow line illustrates the typical generation of electricity during the course of any given day. The orange area represents the demand for communal electricity, while the blue and grey areas represents the combined demand for general electricity and the combined generation of hot water respectively. Due to the fact that South African municipalities does not allow micorgenerators to feedback energy to the grid, the excess electricity either goes to waste or has to be store in batteries; and
- The acquisition and maintenance of batteries on this scale is at this juncture still not economically viable.

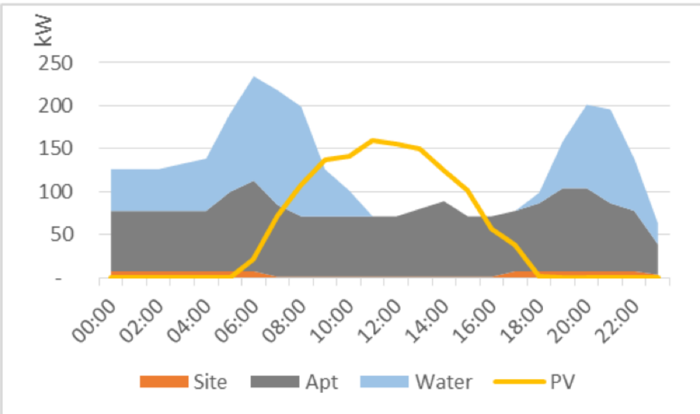

Figure 6.2: Electricity generation and demand cycles in a residential estate

Heat Pumps – Like solar thermal heat pumps have been around for some time. Heat Pump technology involves according to Bianco et.al. [16] the moving of heat from where it is plentiful, to where it can be used for space of water heating, with the assistance of an electric powered pump. The basic principle is similar to vapour compression used in refrigeration, but is makes use of the heat producing end of the thermodynamic cycle. Heat pumps are more efficient when they are powered by reneable energy.

Heat pump water heaters use electricity to move heat from one place to another instead of generating heat directly. Therefore, they can be two to three times more energy efficient than conventional electric resistance water heaters. To move the heat, heat pumps work like a refrigerator in reverse. While a refrigerator pulls heat from inside a box and dumps it into the surrounding room, a stand-alone *air-source heat pump* water heater pulls heat from the surrounding air and dumps it -- at a higher temperature -- into a tank to heat water.

6.1.3 The Sun Village Water Heating solution

The management team of XYZ in consultation with their energy partners realized that a combination of PV, Heat Pumps and the installation of large well isolated cisterns might enable them to make use of more sustainable energy sources and might enable them to reduce operational cost. Figure 5.3 illustrates the conventional warm water generation methodology within a residential estate.

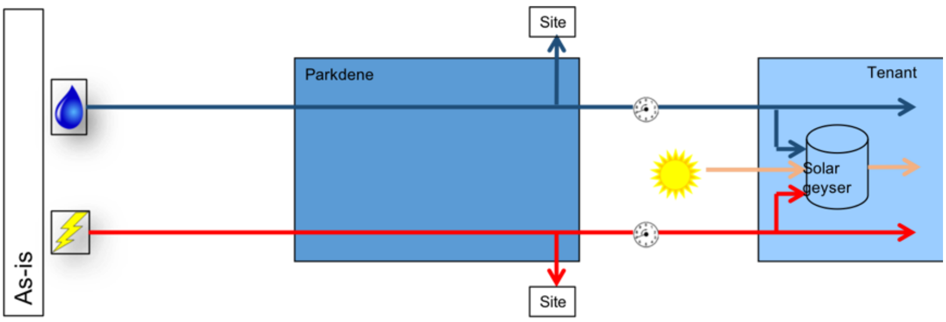

Figure 6.3: Conventional warm water generation

During the conventional process, cold water is acquired from the bulk service provider. Some of this water is used unheated and some water is heated through the solar geyser. The solar geyser is partly heated by the sun and partly heated by conventional electricity acquired from the electricity grid.

The optimized process is illustrated in Figure 5.4. During this process water is still acquired from the bulk service provider, water is however not heated through a solar thermal geyser but through a heat pump and stored centrally in well isolated cisterns. The heat pumps are further-more not powered by conventional electricity acquired from the grid but through PV panels strategically placed throughout the residential complex. All carports roofs for example are PV panels. The dilemma caused by the non-synchronized nature of PV electricity generation and demand within a residential complex as illustrated in Figure 5.1 is thus solved because excess electricity generated through PV are now used to heat water.

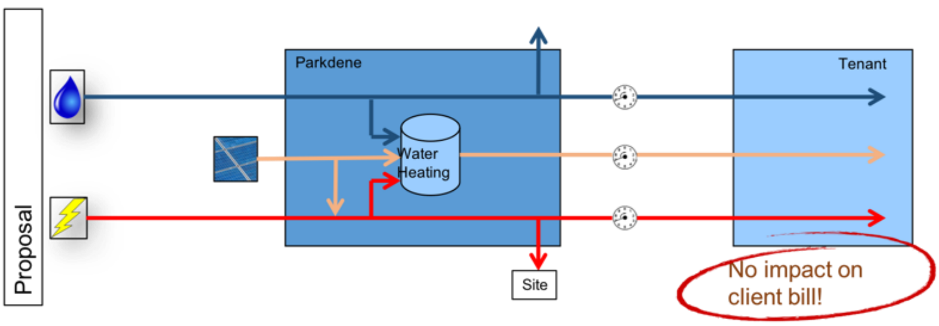

Figure 6.4: Warm water generation through PV and Heat Pump

The optimized supply and demand curves are illustrated in Figure 5.5. During the day when the sun shines the excess electricity generated through PV is used to power heat pump water heaters.

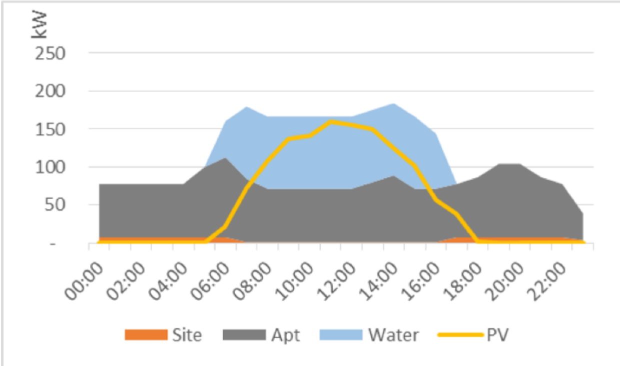

Figure 6.5: Optimized use of electricity generated by PV

The solution thus enabled company XYZ to generate warm water at a fraction of the cost of water generated through conventional methods. The management team of XYZ realized that access to relatively affordable and centrally stored hot water was the key to a number of solutions. A number of additional components were however required to ensure that the full potential of the solution could be unlocked. These components are presented in the following sections.

Although the installation of the Centralised Warm Water System (CWWS) as well as the three smart meters gave XYZ far more control, the absence of an effective utilities management system, an automated warm water shut-off mechanism and a well-defined payment protocol and payment platform however still defeated the efficiency and sustainability objectives of the solution. The development and functioning of these components are briefly discussed in the following sections.

6.2 Smart metering of all utilities

The management of utilities within a large scale residential complex is inherently complex and no standard operating industry mechanism are defined. In newer complexes electricity is normally sold on a pre-paid basis. Tenants acquire tokens at dedicated service providers. A number of relatively recent innovations has streamlined the token acquisition process to a large extent.

Access to potable water is a constitutional right. Due to the perceived high cost involved in the installation of smart meters to regulate the use of water, most residential complexes however make use of conventional water meters. These meters are read manually on a monthly basis and tenants are invoiced a month in arrears. Property managers thus has very little control over water cost recovery. Under recovery of water cost is a huge challenge within the industry and has a very negative impact on total operational cost.

Since access to electricity and warm water is not a constitutional right, the management team of XYZ realized that controlled access to these utilities would place a large amount of control in the hands of the management team. The most effective way to achieve the required levels of control was the installation of smart meters. Every apartment was equipped with three smart meters measuring and the consumption of electricity, cold water and hot water. The distribution and measurement of utilities is presented in Figure 5.6.

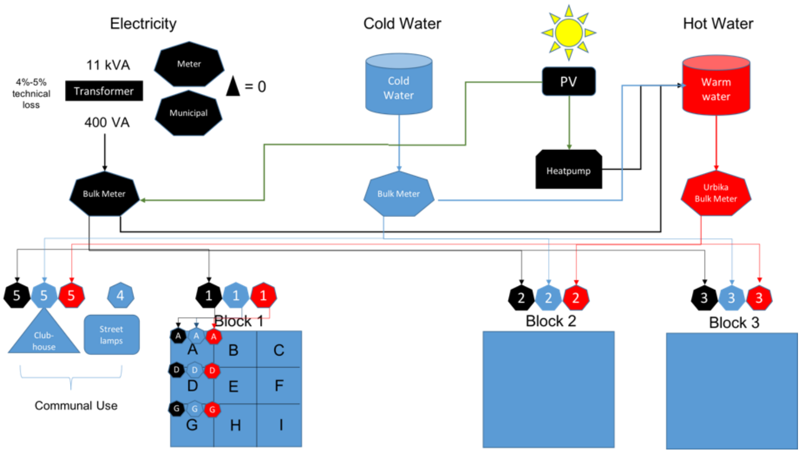

Figure 6.6: Electricity, Cold and Hot Water distribution and measurement

6.3 Shut-off mechanism for the hot water meters

The management team of XYZ realized that the installation of a Centralised Water Heating System can only yield real results if it was possible to efficiently control tenant access to warm water. If warm water control required any form of manual intervention the large scale implementation and maintenance of the solution would become unsustainable. An automatic warm water shut-off mechanism does had to be developed. The mechanism was developed in conjunction with company DEF[5] and consists of a smart meter and a simple ball valve that is remotely controlled via a GSM signal by the Integrated Utilities Management Platform (IUMP) (see discussion in Section 5.4). In the event that a tenant account is in arrears for more than 24 hours, a signal is simply send to the ball valve control mechanism, the ball valve close and warm water is shut down. As soon as the account is no longer in arrears the ball valve open and the tenant has access to the warm water.

6.4 An Integrated Utilities Management Platform

Company DEF had an existing Integrated Utilities Management Platform (IUMP). After minor configuration the platform provided a comprehensive micro-utility solution by incorporating smart meters for each of the three utilities, including a new automated shut-off mechanism for the hot water meters. The advanced tariff engine in the utilities platform enabled XYZ to also tap into the various resell margins which is available to resellers of electricity in the South African market, automating the end-to-end billing process from meter reading through to revenue collection. Using a similar principle as a pre-paid mobile data subscription, the platform's Smart Wallet feature enables XYZ to collect rent as well as utilities revenue (see Section 5.5), without standing the risk of tenants going into arrears on their bills.

The IUMP not only made the utilities management process more efficient, but also enabled XYZ to unlock additional revenue streams.

6.5 An optimized utilities payment protocol

The conventional payment protocol within most residential estates determines that rent is paid in advance on the first day of every month. Electricity is normally supplied by a third party on a pre-paid basis and cold water is billed one month in arrears. The optimized payment protocol as well as consequences for non-payment if illustrated in Table 6.1.

Table 6.1: Non-payment consequence

Order of Payment	Service and payment timing	Consequence of non-payment
1.	Rent – paid one month in advance	- No access to electricity and warm water - Eviction order 7 days after month end - Normal eviction process
2.	Cold water – paid one day in arrears, accurately measured	- No access to electricity and warm water

[5] Company DEF is a pseudo name to ensure confidentiality. The company has core competence in the development and configuration of utilities management software and hardware.

	and reconciled by the smart meter.	
3.	Electricity – paid one day in arrears, accurately measure and reconciled by the smart meter.	- No access to electricity and warm water
4.	Warm water – paid one day in arrears accurately measured by the smart meter.	- No access to electricity and warm water

The implementation of the optimized payment protocol is enabled by the IUMP as well as the Smart Payment Application (SPA) developed by DEF. The basic functioning of the mechanism is presented in Section 5.6.

6.6 Smart Payment Application

The Smart Payment Application (SPA), was developed by company DEF and is downloaded from the iStore or Googleplay store and enables XYZ to invoice the tenant for a number of services including rent, utilities (electricity, cold water and hot water), data, parking and laundry services. The tenant transfers money via the SPA to the bank account of XYZ, but has not control of the allocation of available funds.

The SPA however enables XYZ to prioritize the allocation of paid funds in line with the payment protocol presented in Table 5.1. Apart from the rent that is payable in advance, all other invoices are payable in arrears. The implication of the above prioritized payment methodology is thus far bigger control. Using a similar principle as a pre-paid mobile data subscription, the SPA regulates the tenants access to services. If no funds are available (due to for example overdue rent) in the tenant account hot water and electricity services are automatically suspended until credit is available again.

In addition to the above SPA is also a powerful communication tool.

- The tenant is notified timeously when balances run low to enable timeous fund transfer or top-up;
- The tenant can view available balances and plan further transfers;
- The tenant can view statements;
- The tenant can view all utility usage reports in real-time and is able to compare current utilization with any previous period; and
- The tenant can log maintenance issues via the SPA and receives regular feedback regarding progress.

7. FRAMEWORK EVALUATION

It was clearly stated that the solution had three design objectives, control, process optimization and sustainability. Each one of these objectives were met during the implementation and ongoing management of the solutions framework.

Design Objective	Framework Impact	Evaluation
Control	- Various strategically placed bulk meters enable more accurate control over possible leakage and possible utility theft. - The optimized payment protocol give more control over the timing of rent payment. Late payment result in no access to warm water and electricity. - The solution resulted in 100% cost recovery of electricity, hot and cold water. - Tenants has real time access to usage statistics and can compare current usage with historical usage patterns.	Success

Process Optimization	- The Smart Payment Application optimized the often cumbersome acquisition of utilities for tenants. - IUMP automates the control process and no human intervention is required. - The algorithms governing the process ensures that services are suspended and reinstated without any human intervention. •	Success
Sustainability	**Environmental sustainability** - 90% of the electricity needed to generate hot water is derived from PV panels. • **Financial sustainability** - The optimized cost recovery of utilities lead to a reduction of at least 1,5% in total operating cost. This has a huge long-term impact on the investment case. - The automated process requires far less human intervention, which resulted in significant cost savings on the part of the property manager. - The margin on the sale of hot water funds the additional Capital Cost required to implement the solution. The payback period is 7,5 years.	Success

8. CONCLUSION

The objective of this paper was to illustrate how the application of FIR technology and principles during the construction and management of a residential housing development can add value and contribute to the well-being of property owners, managers and residents.

In order to achieve the objective the following aspects were presented in the paper. In Section 2 the South African Residential Housing Landscape was briefly discussed. The section concluded with an estimate of the nature and extent of urban housing demands over the next 12 years.

In Section 3 institutional investment and management of residential housing complexes were discussed. The section concluded with a presentation some of the major challenges faced by property managers within this industry. In Section 4 the Sun Village residential estate was briefly described. The solution framework was developed and deployed within the Sun Village estate.

In Section 5 the solutions framework was presented. It was explained that the framework consisted of six components namely a Centrailised Hot Water System powered by a PV plant, smart metering of three utilities (electricity, cold water and hot water), an automated shut-off mechanism for hot water, an Integrated Utilities Management Platform, an optimized utilities payment protocol and a Smart Payment Application.

Finally the framework impact was evaluated against the stated design objectives. In Section 7 it was illustrated that the application of FIR technology and principles can indeed add value to a broad spectrum of stakeholders within a residential housing development.

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