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Backlog Reduction in Housing Provision Process using Mixed Approach of DMAIC, SMART and AHP Methodologies

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Abstract. *To support its oil operation, IEC manages four camps which most of its facilities require significant repair, especially its housing complexes. Vacant houses with good condition only available in very limited numbers and were not enough to fulfill all housing requests. In the same time, recent business environment forced company to reduce operational expenditure in building maintenance. Limited numbers of vacant houses, limited budget for building maintenance and higher number of housing requests have created a long waiting list and high backlogs in housing assignment list. This research objective is to analyze the existing process of housing provision which has high backlogs in housing assignment list and to propose the intervention to improve it. Combination of DMAIC (Define, Measure, Analyze, Improve, Control) and Decision Analysis methodologies will be used to explore and solve the issue. Based on the analysis performed, root causes of this problem are no proper prioritization tools in place, no dedicated personnel to enable the task, and outdated policy. Hence, the proposed solutions to solve the problem are: prioritization tools are developed and improved for housing renovation and housing assignment processes, dedicated person is assigned to manage housing provision process and internal housing policy is revised and updated. As the result, with strong support from Leadership and collaboration between cross-functional team, the backlogs in housing assignment list can be reduced to 0 (zero). However, improvement in housing renovation process is still needed, especially in reducing cycle time in perform renovation task.*

Keywords: *DMAIC, Decision analysis, SMART, AHP, housing provision*

Abstrak. *Untuk mendukung kegiatan operasinya, IEC mengelola empat kamp yang sebagian besar fasilitasnya membutuhkan perbaikan, terutama kompleks perumahan. Rumah kosong dengan kondisi baik hanya tersedia dalam jumlah yang sangat terbatas dan tidak cukup untuk memenuhi semua permintaan perumahan yang ada. Di saat yang bersamaan, kondisi bisnis saat ini memaksa perusahaan untuk mengurangi biaya operasional untuk pemeliharaan bangunan. Terbatasnya jumlah rumah yang kosong, terbatasnya anggaran untuk pemeliharaan bangunan dan tingginya jumlah permintaan rumah telah menciptakan daftar antrian panjang dan backlog yang tinggi pada daftar penempatan perumahan. Penelitian ini bertujuan untuk melakukan analisis pada proses penyediaan perumahan saat ini yang memiliki backlog tinggi dalam daftar penempatan perumahan dan untuk mengusulkan intervensi untuk memperbaikinya. Kombinasi metodologi DMAIC (Define, Measure, Analyze, Improve, Control) dan Analisis Keputusan akan digunakan untuk mengeksplorasi dan memecahkan masalah ini, Berdasarkan analisa yang dilakukan, akar dari masalah ini adalah tidak adanya alat prioritisasi yang layak, tidak adanya personil yang bertugas untuk melakukan pekerjaan tersebut dan kebijakan perusahaan yang tidak diperbarui. Oleh karena itu, solusi yang diusulkan untuk mengatasi masalah ini: alat prioritisasi dikembangkan dan ditingkatkan untuk proses renovasi dan penempatan perumahan, seseorang diberi tugas untuk mengelola proses penyediaan perumahan dan kebijakan internal perumahan direvisi dan diperbarui. Sebagai hasilnya, dengan dukungan kuat dari pimpinan perusahaan dan kolaborasi dari tim lintas fungsi, backlog di daftar penempatan perumahan dapat dikurangi menjadi 0 (nol). Namun, perbaikan proses renovasi perumahan masih diperlukan, terutama dalam mengurangi waktu dalam melakukan tugas renovasi.*

Kata kunci: *DMAIC, analisis keputusan, SMART, AHP, penyediaan perumahan*

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Introduction

Indonesia Energy Company (IEC) is a subsidiary of Energy Corporation, one of leading energy companies in the world. IEC operates the oil operations in West Operation area in partnership with the Government of Indonesia through Production Sharing Contract (PSC). To support its operation, IEC operates four major camps, namely *Wind*, *Hydro*, *Heat* and *Solar* camps. Facility Management (FM) West Operation (WO) Unit Function holds an important role in supporting IEC operation. Both Facility Management Service (FMS) and Facility Management Maintenance (FMM) teams under FM WO have responsibility to manage IEC camp facilities. One of critical process in FM WO is providing company housing to eligible employees as mandated in company internal policy.

Housing Provision Process

The company housing provision process starts with changes in HR manning table every month. These changes can be in the form of grade, marital status or location changes. Once the changes exist, the FMS team enters the information into the housing waiting list.

In this step, the employees are sorted and prioritized based on housing points. To continue the process, FMS team needs list of available vacant houses to be offered to employees from FMM team. After that, FMS team then starts the housing selection process by offering the housing list to the employees based on their housing points. The higher the housing points the higher the chance for the employee to get his/her preferred house. Once it completes, FMS team develops housing assignment proposal. Next step, FMS team routes the housing assignment proposal to FM WO and ISBU Managers to get an approval. Once it approves, FMS team forwards the proposal to Camp Council to get an endorsement. After getting the endorsement, FMS team announces the housing assignment and sends the housing assignment notification to employee's direct leader.

To complete the process, employee must return the signed notification letter stating agree or disagree with the assignment within 2 weeks. Detail of housing provision process is shown in Figure 1.

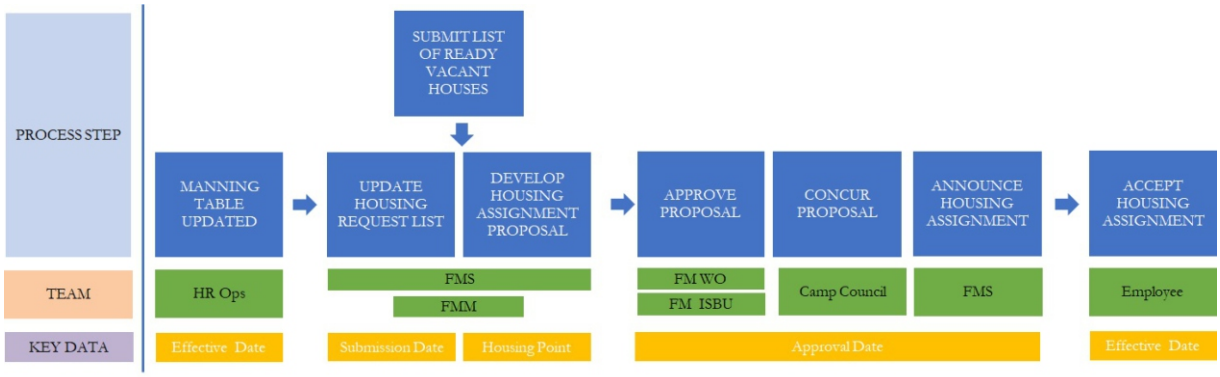

Figure 1. Current Housing Provision Process (Source: IEC, 2015)

As shown in above figure, there are 2 teams involved in the current housing provision process. FMS team manages the overall process of housing assignment, while FMM team manages housing renovation and provides ready vacant houses. Housing assignment process cannot be completed if no ready vacant house from FMM.

Issues in Managing Company Housing

Limited Vacant Houses

IEC camp facilities consist of offices, housing complexes, sport and public facilities. Those facilities were built more than 30 years ago and most of them require significant repair, especially the housing complexes. At the end of 2015, West Operation (WO) camps have reached 88% of housing occupancy rate and had only 260 units of vacant houses from total 2,252 units. From those limited vacant houses, 87% of them are needed to be repaired. These conditions are illustrated in Figure 2 and 3.

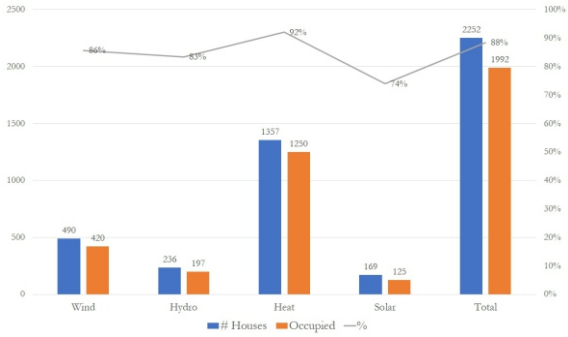

Figure 2. Housing Occupancy Status

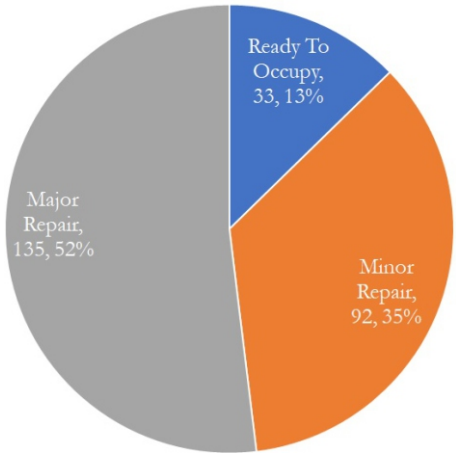

Figure 3. Vacant House Status

Limited OPEX for Building Maintenance

In recent business environment with lower oil price and closer PSC expiration, it is no cost-efficient to construct new company facilities. In other hand, to run, maintain and manage aging facilities also require a huge spending in operational expenditure (OPEX). In 2015, building maintenance spent 34% of overall FM OPEX and shows increasing trend compare with previous year. FM West Operation is requested to reduce operational expenditure in building maintenance for year 2016.

Higher Number of Housing Requests

Current internal policy mandates IEC to provide housing for its employees. There are 3 (three) types of housing in West area, namely Type I, III and IV. The eligibility requirement of each of housing types are based on employee's Pay Scale Grade (PSG). Generally, number of housing requests in all camps are increased for certain types of housing. Most of the requests were coming from the employees who have eligibility to move to higher type of house once he/she promoted to higher range of PSG. Furthermore, inter region and inter district transfers due to recent organization changes also contribute to increase the housing requests.

The total 260 units of vacant houses were not enough to fulfill all 318 housing requests recorded in the system. In the same time, due to cost reduction initiative in FM WO, the number of houses being renovated by FMM team was only 54, which resulted number of assigned house was decreasing sharply compare with last year. By having these conditions, there were 264 housing requests that could not be assigned and identified as the backlogs in the housing assignment at the end of 2015. Following figure shows the housing assignment status as of December 2015.

Limited numbers of vacant houses, limited budget for building maintenance and higher number of housing requests were listed as business issues and identified as an improvement opportunity in FM WO.

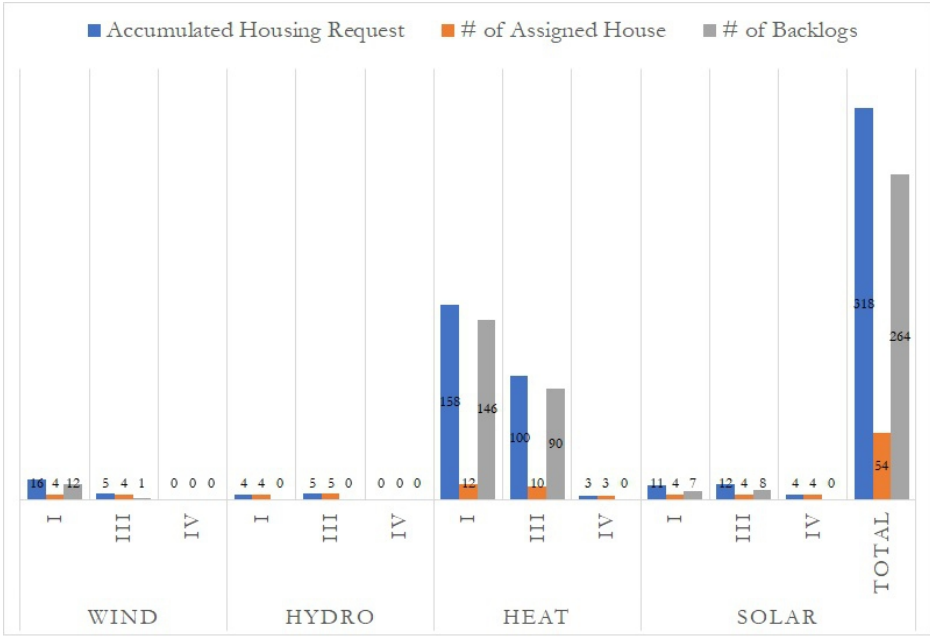

Figure 4. Housing Assignment Status

The objective of this research is to improve the housing provision process which has high backlogs in the housing assignment list. Both IEC as company and its employees agreed that current business process needs to be improved, so that number of backlog can be reduced. To explore and solve the business issues, combination of DMAIC, SMART and AHP methodologies will be used accordingly.

This research will focus on the following questions:

1. Why is IEC housing assignment process having high backlogs?
2. What should IEC do in order to reduce the backlogs?
3. What should IEC do in order to sustain the improved process?

DMAIC for Process Improvement

To identify whether this improvement opportunity will be suitable to be executed as DMAIC project, Project Feasibility Tool as shown in Table 1 was used. Based on the checklist result, it concluded that DMAIC was the right approach to be applied in this research. DMAIC is a structured approach for problem solving and process improvement. It is often used in Lean or Six Sigma (LSS) approaches to define the stages of the project. For the last two decade's history in literature, many researchers have found about DMAIC methodology. Sehgal and Kaushish (2015) concluded that number of industries adapting this approach to solve any quality or production related problems.

Table 1
Project Feasibility Tool

No	Project Pre -Assessment Feasibility Checklist	Yes, No, Unknown
1	Is this an existing process? (Y)	Yes
2	Is the scope of the process too large to complete in 5 months? (N)	No
3	Is the process complex? (Y)	Yes
4	Would this be regarded as a capital project? (N)	No
5	Is the solution to this problem already known? (N)	No
6	Is the performance data readily available? (Y)	Yes

This approach has been utilized by manufacturing and service industries and applied in any small or medium scale industry to eliminate any customer of product related problem.

Snee (2000) defined that the basic concept behind the DMAIC approach is to reduce product and process variation at carriage and wagon works. Results showed that 5.9% of rejections were reduced. Horel (2001) described that the DMAIC was firstly applied in manufacturing industry and rapidly expanded to different areas such as marketing, engineering, purchasing and servicing. Result showed that Whirlpool company has successfully increased its quality by 10% by adopting DMAIC. Kim Yong et al (2010) conducted a case study into a corporate research library of a telecom company in Korea. DMAIC was used to identify key factors that have effect on information acquisition time and information utilization.

Chakrabortty, Biswas and Ahmed (2013) used DMAIC model in food producing industry in Bangladesh. This method is used to reduce product defect which decrease the company's benefits and customer's satisfaction. Singh & Lal (2016) applied DMAIC methodology in manufacturing industry to improve the process performance. Result showed that rejection rate in the muffler plant was controlled from 8.21% to 4.81% and the process yield was increase from 91.73% to 95.19%. Kusnadi (2016) presented DMAIC to tackle a managerial problem of contractor' work preparation time in oil and gas industry. As the result, start time working at the field reduced to around 8:11am and available working time per day improved.

In its application, there are 5 (five) phases in DMAIC; namely Define, Measure, Analyze, Improve, and Control.

Define Phase: aims to explore the business issue that faced by the company and assigned specific project team with clear objective. In this phase, problem will be clearly identified. Team and its Sponsor will reach an agreement on the scope, goals and financial target for the project (George et al, 2005).

Measure Phase: aims to understand the current state of the process and identify parameters that affects process performance. In the Measure phase, team will thoroughly understand the current state of the process and collect required data to establish baseline (George et al, 2005).

Analyze Phase: aims to identify the root cause of the problem and prioritize them. In this phase, team will identify and verify the root causes that affecting the project goals.

Improve Phase: aims to identify and implement the solution to solve the problem. In this phase, team will identify, develop and implement solution.

Control Phase: aims to complete the project work and hand over the improved process to the process owner, with procedure to sustain the gains (George et al, 2005).

DMAIC has gained important attention in business field due to its financial impact and levels of customer satisfaction. Companies which have adopted it have reported increase financial performance in short term (Thomas et al, 2009), cost reduction (Anchanga, 2006), improvement in customer satisfaction and cost saving (Sharma, 2003). Breyfogle (2004) affirmed that the DMAIC approach has proved itself highly effective in terms of delivering cost saving and increased customer satisfaction.

Combination SMART & AHP for Decision Analysis

Based on analysis performed, it was noticed that there were no proper prioritization tools for both housing renovation and housing assignment processes. Hence, the development and improvement of both prioritization tools are required. For these purposes, decision analysis methodology is used. There are 3 alternatives of decision analysis method that consider to be used in this research: Simple Multi-Attribute Rating Technique (SMART), Analytic Hierarchy Process (AHP) and combination of SMART and AHP.

SMART

SMART has been widely applied because of its relative simplicity and transparency, which means that the decision makers from many background can easily apply the method and understand its recommendation (Goodwin et al, 2010: 33). It provides easier method to measure the performance of each alternative, which is evaluated through a direct rating method.

AHP

AHP is general theory of measurement through pairwise comparison and relies on the judgments of experts to derive priority scales (Saaty, 2008). AHP is popular and widely used for multi-criteria decision making. It allows the use of qualitative, as well as quantitative criteria in evaluation.

There are many researchers on SMART /AHP methodologies in the history of literature, such as Hariandja (2016) used SMART method to reduce work order active in a maintenance team, Filho et al (2005) applied SMART to construct a multi-criteria decision model for software selection, Vachnadze (2016) described AHP in providing an integrated approach that prioritizes organizational performance measures, Kravchenko and Seredenko (2011) provided an approach to the modeling of economic decision-making problem situation using the Analytic Hierarchy Process and Avila et al (2015) studied about an empirical model for suppliers' selectin that can be applied with the AHP or SMART method.

In this research, AHP cannot be fully implemented since it is difficult to compare large number of alternatives and assign different priority number. This difficulty will be resolved by using direct rating method in SMART which rating the large numbers of alternatives quickly with adequately close result (Saaty, 2008). Hence, combination of both methods is the best fit to be applied into the solution. The stages of this combination method are listed below:

Stage 1: Identify the decision maker(s).
Stage 2: Identify alternative courses of action
Stage 3: Identify relevant criteria and attributes
Stage 4: Assign values for each attribute to measure the performance of the alternatives on that attribute with Direct Rating
Stage 5: Make pairwise comparison to determine the weight of each criterion
Stage 6: Sum the weighted average of values assigned to alternatives
Stage 7: Prioritize the alternatives based on the sum of weighted average

In literature, there are very limited researchers that have used combination SMART and AHP. Kasie (2013) revealed the importance of combining SMART and AHP for selection of Key Performance Indicators (KPIs). Victor (2016) also used combination of SMART and AHP to improve prioritization process in oil and gas industry. Both studies highlighted criticality in criteria selection. Kasie (2015) selected strategic fit and accessibility and Victor (2016) chose cost, duration and business impact. Al-Harbi (2001) selected the most suitable contractor with financial stability and quality performance criteria.

The application of Multi Attribute Decision Making (MADM) together with DMAIC is very limited. In this research, DMAIC framework was implemented in an oil and gas industry to improve the existing process. The difference between this research from the others is in terms of tools used in conducting this research and its perspectives.

Research Methodology

For analyzing high backlogs in the housing assignment list and presenting the preferred approach to improve it, a simple DMAIC framework is used in this research. DMAIC was selected as an approach because it has been adopted by Energy Corporation as a proven tool in process improvement for all its worldwide operation including in IEC. By using this framework, it is expected that these improvement activities can be managed in structured manner. Detail of this process is shown in Figure 5.

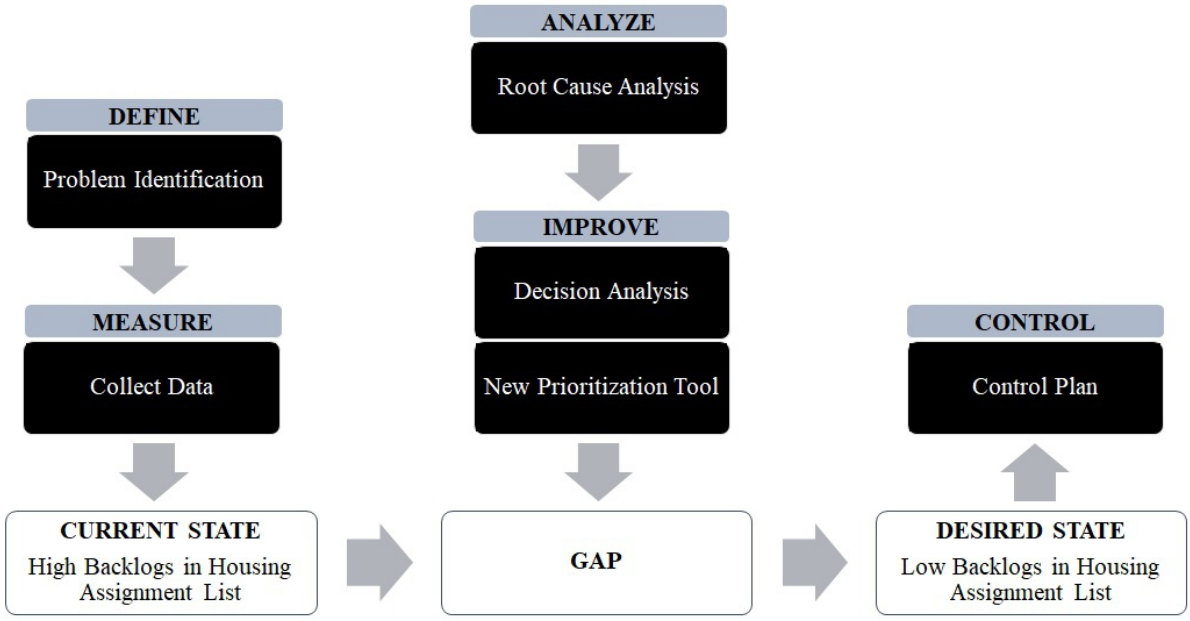

Figure 5. Conceptual Framework

Methodology used in this research is a mixed of qualitative and quantitative method. It began with a qualitative research phase, followed by data analysis that used to build into a quantitative phase (Creswell, 2014). The business issue identified in this research came from numerous observations by the process owner and management. The bottom-up approach came from employees in FM WO unit function that stated their concern on the current housing provision process. The formal report of these observations and the gaps are available in the forms of emails and minutes of meeting.

The top-down approach came from FM WO/ISBU Managers that requested the cost reduction initiative to be applied in the building maintenance. These observations were then used as Voice of Customer. The quantitative approach was performed in two steps. It started with mapping of current housing assignment process and collecting measurement data from FMS and FMM teams. These data were collected from January – December 2015 period. The objective of these two steps were to understand the current situation and to raise up the issue for improvement.

This research is implemented within five months from Define to end of Improve phase and continued with 12 months monitoring in the Control phase. Define phase started with problem identification. In this phase, team and its Sponsor reached an agreement on the scope and goal for the project. During this phase, qualitative data was used and additional interview was conducted. The result was translated into Critical Customer Requirement.

These qualitative data were then validated during the Measure phase to establish the baseline. During the Analyze phase, brainstorming session was conducted to identify the root causes that affecting the project goals. Once its identified, team developed the solution to solve the problem as part of the Improve phase. To close the gap and move to the desired state of low backlogs in the housing assignment list, combination of SMART and AHP methodology is used in the prioritization tools. Finally, the results of the improvement in the Control phase were monitored for 12 months to sustain the result.

Results and Discussion

The results of DMAIC implementation will be discussed phase by phase starting from Define to Control phase.

Define Phase

Understand the Voice of Customer (VoC)

Voice of Customer is defined as a specific customer's point of view on product or service issues. The customer for this project are FMS, FMM, FM and HR leadership, and employees whose names listed in housing assignment list.

To collect the VoC, interview to several key customers were conducted. These voices then translated into Customer Critical Requirement as seen in Table 2.

From the table, it can conclude that it is desired for both FM team and affected employees to have an improved housing provision with clear and consistent implementation process in WO.

Table 2.
Translation Table of Voice of Customer into Customer Critical Requirement

No	Voice of Customer	Customer	Clarification	Customer Critical Requirement
1	There are significant number of backlogs in housing assignment list	FMS team and FM Leadership	Based on internal record, number of backlogs have increased from month to month	Backlogs for housing assignment are reduced
2	Camp Council has prerogative right to prioritize housing assignment	Employees	Sometimes employee with lower housing points can get his/her housing assignment earlier than others with higher points	Clear and consistent process across West Operation area
3	Company has outdated policy on housing provision	FM & HR Leadership	The current housing policy has not updated since 2011, and not aligned with current business strategy	Housing policy is updated and aligned with business strategy
4	Building maintenance cost shows increasing trend compare with previous year	FM WO / IBU Managers	The operational expenditure for building maintenance of FM is trending up in 2014 and 2015	OPEX for building maintenance is reduced

Scope the project

As part of project deliverables in Define phase, Input Process Output (IPO) diagram was also developed. IPO diagram for this project is shown in Figure 6. To formalize this project, an important document called Project Contract is utilized. Generally, project contract includes the business case, problem statement, goal statement and project scope.

Measure Phase

Check the measurement system and collect the baseline data

As stated in Figure 6 of IPO diagram, number of backlogs is expected output metric from this project that needs to be measured. It is calculated by using below formula:

[B] Backlogs = [R] Accumulated Housing Requests – [A] # of Assigned House

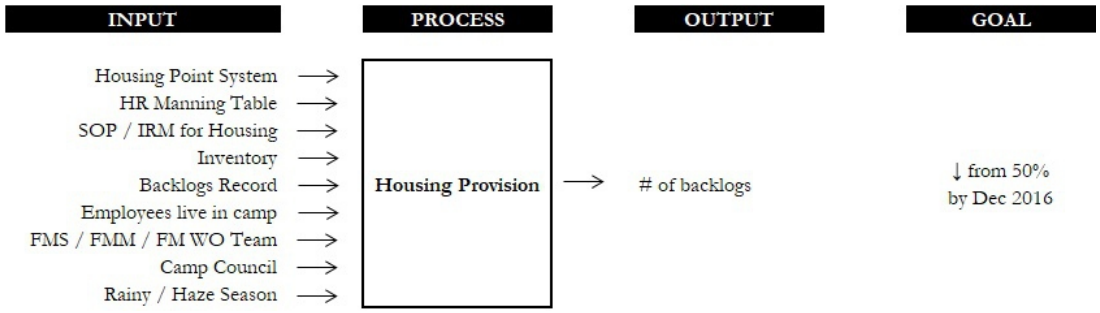

Figure 6. IPO Diagram

All data related to housing request and vacant house will be shared to the project team. Those data then presented using excel charts for further analysis, as shown in Figure 4.

Analyze Phase

Determine the source of defect

Using the housing request data, team noticed that most of housing requests were coming from Within District, PSG 20 and for Type I and III. Following figures show the housing request status by moving type, housing type and PSG.

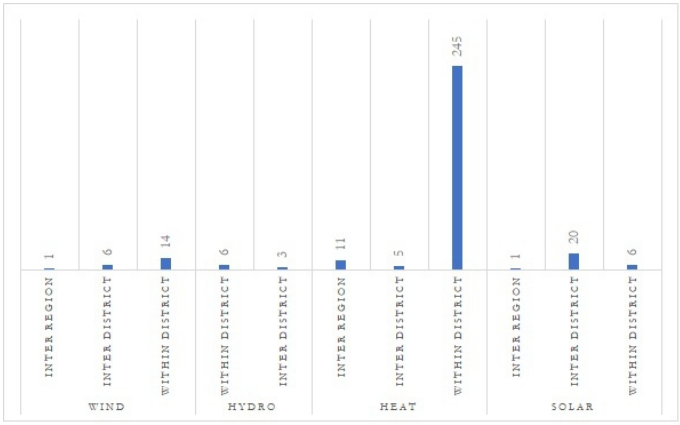

Figure 7. Housing Request by Moving Type

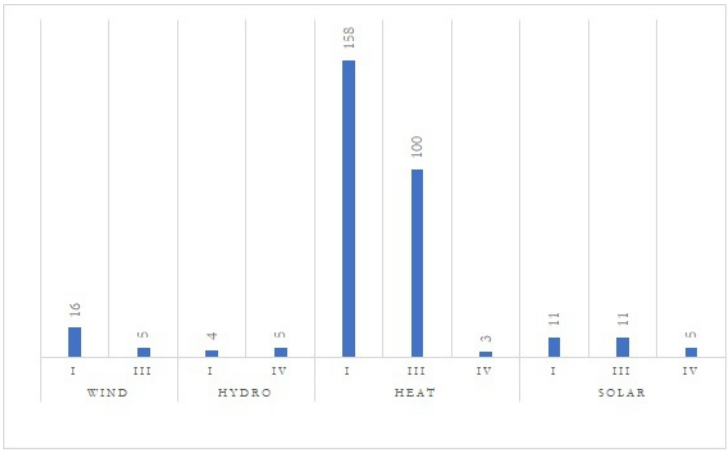

Figure 8. Housing Request by Housing Type

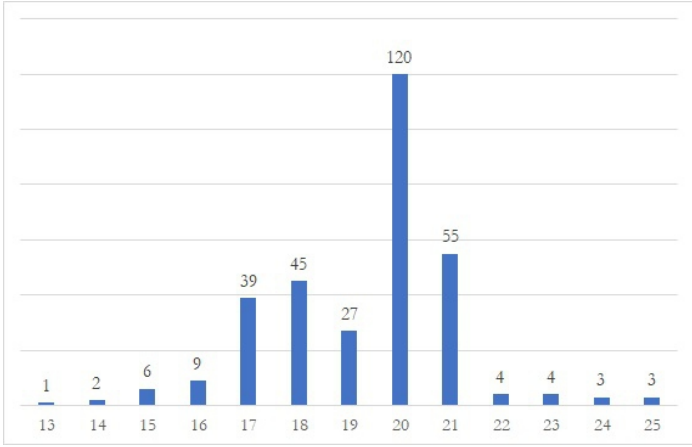

Figure 9. Housing Request by PSG

Identify potential root cause, analyze and verify root cause.

In this step, team developed fishbone diagram. Fishbone diagram is a tool for root cause analysis, developed by Dr. Kaoru Ishikawa, which describes the problem and the causes, in a fish skeleton image (Barsalou, 2015). The problem stated in the "fish head" is high backlogs in housing assignment list as shown in Figure 10. There are four categories used to find the root causes: Budget, Environment, Resources and Process. During the brainstorming session in developing fishbone diagram, team used Five Whys through question as shown in Table 3.

In this research, Five Whys is used as part of the fishbone diagram to drill down the root causes, verify if a problem has more than one root cause, and determine the relationship between different root causes of a problem. According to Pojasek (2000), the Five Whys is used by asking "why" at least five times through various level of detail. Once it becomes difficult to respond to "why" the probable cause of the problem may have been identified.

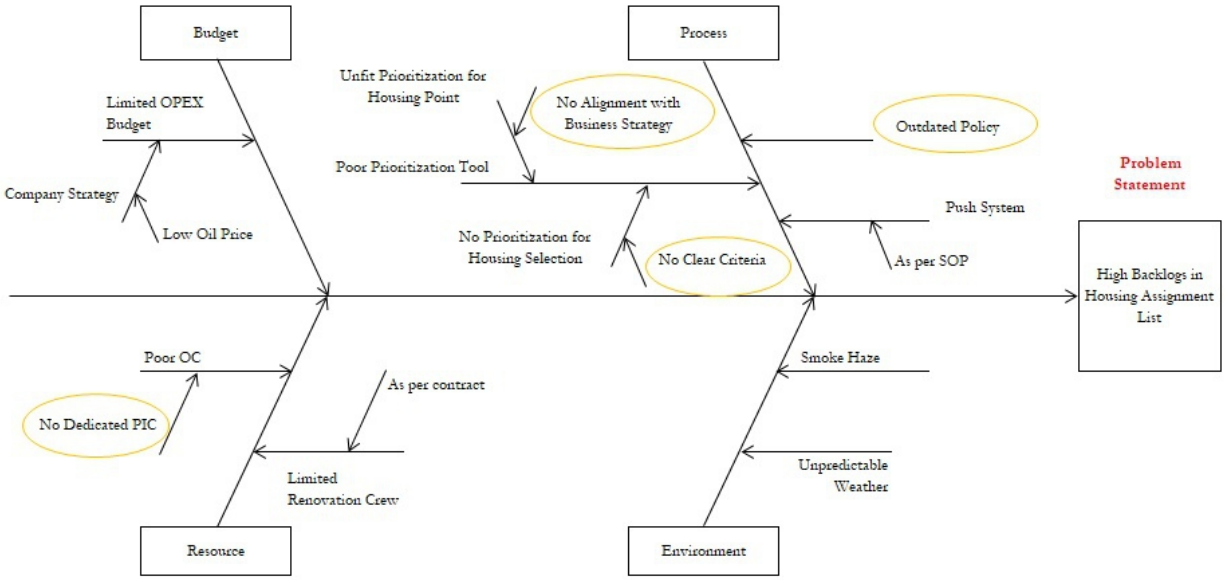

Figure 10. Fishbone Diagram

Table 3.
Five Whys on High Backlogs in Housing Assignment List

No	Why 1	Why 2	Why 3	Why 4	Why 5
1	Because company has limited number of vacant houses to be offered to employees	Most of the houses are already occupied by the employees	Company mandated to provide housing to the employees	It states in the current IRM	No updated policy in place to prevent such thing from happening
		Some of vacant houses requires major renovation	Most of the houses were built 30 years ago	It was required by business at that time	
2	Because company has limited budget to do housing renovation	Company decided to reduce operational cost in 2016	It is aligned with company business strategy	In effort to ensure company survivability in low oil price business environment	
3	Because there are changes in HR manning table	Employees are promoted to higher PSG	Employee are eligible to move to higher type of house within district	It states in the current IRM	No update policy in place to prevent such thing from happening
		Employee status are changed from single to married	Employee are eligible to move from bachelor quarter to family housing	It states in the current IRM	
		Employee are transferred to the new camp location	It is required by business		
4	Because company has limited resources in handling housing provision process	Poor organization capability	No PIC to coordinate overall housing provision process	It is based on current FM organization structure	No position in place to enable this task
		Limited renovation crew	It states in the contract		
5	Because most of housing requests are still in housing assignment proposal	Poor prioritization tools	Unfit formula for housing point calculation	No alignment with company business strategy	No proper formula in place
			No prioritization for housing renovation	No clear criteria	No proper prioritization tool in place
		"Push System" from HR manning table	It states in the Standard Operating Procedure (SOP)	No procedure in place to prevent such thing from happening	

Based on the analysis performed, the root causes of high backlogs in housing performance lists are no clear criteria and no alignment with business strategy in the current processes, no dedicated PIC for housing provision process and outdated policy. The analysis summary of the problem identified earlier can be seen in Table 4.

Improve Phase

Generate potential solutions

As described in Table 4, there are 5 controllable causes that need to be addressed.

In current housing provision, there is no synergy between FMS and FMM team. FMM do not know number of houses that will be completed its renovation in the near future. Meanwhile, FMM team also do not know number of housing requests listed in particular month. The solution that is offered is to improve organization capability in FM by assigning FM Planning Specialist as dedicated person for managing housing provision process.

Table 4
Business Analysis Summary

Category	1st Cause	2nd Cause	3rd Cause	Remarks
Budget	Limited OPEX budget	Align with company strategy	Low oil price	Uncontrollable
Environment	Unpredictable weather			Uncontrollable
	Smoke haze			Uncontrollable
Resource	Poor organizational capability in handling housing provision process	No dedicated PIC		Controllable
	Limited renovation crew	As per contract		Uncontrollable
Process	Outdated housing policy	Last revision in 2011	No urgency in updating policy	Controllable
	"Push System" start from updated HR manning table	As per SOP		Controllable
	Poor prioritization process	No prioritization tool for housing renovation	No clear criteria in prioritizing	Controllable: Research Focus
		Unfit calculation formula for housing point	No alignment with company business strategy	Controllable: Research Focus

Housing assignment process was triggered by changes in HR manning table. There are 3 types of changes: PSG range, status and location changes. Each change will create additional entry of housing request in housing waiting list. The solution is to change the "Push System" to "Pull System". By having "Pull System", the housing waiting list will not be updated until received formal request from employee concerned.

Internal Relation Manual (IRM) for company housing was developed firstly in year 1990. Some changes have been made during its implementation. However, there are opportunities for improvement in current process, considering this policy has not been updated since 2011. The solution is to review and update the housing policy to be aligned with current business environment faced by IEC. Following table shows list of changes that will be captured in the new updated housing policy.

Table 5
Changes in Housing Policy

No	Current Policy	New Policy
1	Company mandated to provide housing for its eligible employees	Company may provide company housing based on availability basis on eligible employees
2	There are 3 types of housing based on PSG range: Type I for PSG 20 and up Type III for PSG 16 – 19 Type IV for PSG 10 – 15	There will be 3 types of housing cluster based on new PSG range: Cluster A for PSG 22 and up Cluster B for PSG 16 – 21 Cluster C for PSG 10 – 15
3	Housing request list is automatically updated based on changes in HR manning table	Housing request list will be updated based on employee request
4	Moving within district is possible, especially to move to higher type of house, if an employee gets promotion	Moving within district is not allowed, except for HES (Health, Environment, Safety) reason and new housing request from newly married / new hire employee
5	Housing point calculation formula: HP = SC + SD + MT Where SC: Salary Class; SD: Service Duration; MT: Moving Type	New formula for housing point calculation will be applied

In housing assignment process, FMS team has an urgency to align the housing point calculation with updated housing policy. Meanwhile, in housing renovation process, FMM team has a roadblock on their process. Normally, FMM team renovates the housing unit once the occupant checks out from the facility. This practice was then stopped due to budget limitation in building maintenance. FMM team needs clear criteria to prioritize which vacant houses that need to be renovated. Prioritization tools are needed to address both issues.

Decision Analysis Tools

Decision analysis method will be used to develop prioritization tools for both processes in FM. For this purpose, combination of SMART and AHP is selected as decision analysis method based on FM organization expectation.

Housing Renovation Process

The prioritization tool for Housing Renovation process will help FMM team in prioritizing which vacant houses need to be renovated in relation with limited operational budget. Following are the step by step taken in the process.

Criteria Selection

Criteria selection is the key process to address the business issue. Criteria for the prioritization tools are determined based on interview process with the Subject Matter Experts (SMEs). To generate list of housing renovation, FMM team collected detail information of housing to be renovated. SMEs identified four new criteria during the interview process: Cost, Schedule, HES Risk and Strategic Fit. The SMEs agreed that by introducing those criteria to the prioritization process, it can help company to set priority for housing to be renovated and optimize the operational expenditure for building maintenance.

Criteria Analysis

Once the selection of criteria is completed, the next important step will be criteria analysis. In this step, attributes will be determined for each criterion. Analysis to the current vacant houses is performed to determine the attributes range for each criterion.

- *Cost:* This criterion refers to total cost spent by company to renovate each vacant house.
- Schedule: This criterion refers to length of time to complete renovation for each vacant house.
- *HES Risk:* This criterion refers to level of HES risk to complete renovation for each vacant house.
- *Strategic Fit*

  This criterion refers to alignment of each vacant house (asset) with company's strategic plans, such as Reduce Foot Print and Solar Rotator Camp. The attributes for this criterion are determined by categorizing each vacant house with 3 type of levels. Level 0 means that the asset is not listed in any strategic project. Level 1 means that the asset is listed in one of the strategic project. Level 2 means that the asset is listed in all strategic projects.

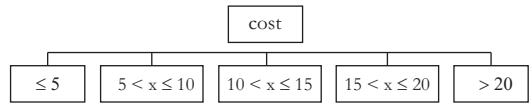

Figure 11. Attributes for Cost

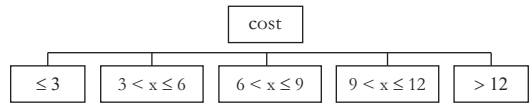

Figure 12. Attributes for Schedule

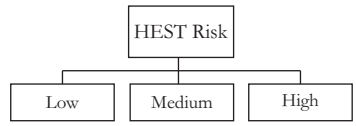

Figure 13. Attributes for HES Risk

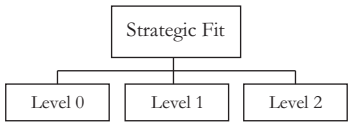

Figure 14. Attributes for Strategic Fit

Direct Rating

To provide simplicity and transparency in the prioritization process, direct rating is chosen as preferred method. Direct rating assigns value directly to various attributes given to a criterion.

For this purpose, each attribute will be given value between 0 and 100 to quantify its degree of importance in specific criteria. The value given to each attribute in cost, schedule, HES risk and strategic fit is shown in Table 6 and Table 7.

Pairwise Comparison

Pairwise comparison is a method to compare an element one another (pairwise) to obtain value of their respective interests. This method is used to compare each criterion in this research. To determine the scale of each criterion to another, Focus Group Discussion (FGD) is formed. Leaders in FM are requested to participate in the session. During the FGD session, participants stated their opinions on degree of importance or dominance between one to another criterion. Each comparison was discussed until it was agreed to one numerical rating. The discussion result can be seen in Table 8.

Table 6
Direct Rating for Cost and Schedule Criteria

	Criteria		
	Cost (US$ 000)	Schedule (months)	Value
Attribute	> 20	> 12	0
	15 < x ≤ 20	9 < x ≤ 12	25
	10 < x ≤ 15	6 < x ≤ 9	50
	5 < x ≤ 10	3 < x ≤ 6	75
	≤ 5	≤ 3	100

Table 7
Direct Rating for HES Risk and Strategic Fit Criteria

	Criteria		
	HES Risk	Strategic Fit	Value
Attribute	High	2	0
	Medium	1	50
	Low	0	100

Table 8
Criteria Pairwise Comparison – Agreed Result

No	Question	Degree of Importance	Scale
1	How importance is cost to schedule?	Moderately more important	3
2	How importance is cost to HES risk?	Slightly more important	2
3	How importance is cost to strategic fit?	Slightly less important	1/2
4	How importance is schedule to cost?	Moderately less important	1/3
5	How importance is schedule to HES risk?	Slightly less important	1/2
6	How importance is schedule to strategic fit?	Moderately plus less important	1/4
7	How importance is HES risk to cost?	Slightly less important	1/2
8	How importance is HES risk to schedule?	Slightly more important	2
9	How importance is HES risk to strategic fit?	Moderately less important	1/3
10	How importance is strategic fit to cost?	Slightly more important	2
11	How importance is strategic fit to schedule?	Moderately plus more important	4
12	How importance is strategic fit to HES risk?	Moderately more important	3

Synthesizing

Synthesizing is the next step in AHP to weight the criteria by using the scales obtained from the pairwise comparison. The desired output of this process is to have weighted criteria to be used further in the prioritization process.

Following steps illustrate the synthesizing process for Housing Renovation.

Step 1: Sum the values in each column

Step 2: Divide each element of the matrix by its column total

Step 3: Average the elements in each row

Table 9
Synthesizing – Step 1

Criteria	Cost	Schedule	HES Risk	Strategic Fit
Cost	1	3	2	1/2
Schedule	1/3	1	1/2	1/4
HES Risk	1/2	2	1	1/3
Strategic Fit	2	4	3	1
Total	23/6	10	13/2	25/12

Table 10
Synthesizing – Step 2

Criteria	Cost	Schedule	HES Risk	Strategic Fit
Cost	6/23	3/10	4/13	6/25
Schedule	2/23	1/10	1/13	3/25
HES Risk	3/23	2/10	2/13	4/25
Strategic Fit	12/23	4/10	6/13	12/25

Table 11
Synthesizing – Step 3

Criteria	Cost	Schedule	HES Risk	Strategic Fit	Row Average
Cost	0.261	0.300	0.308	0.240	0.277
Schedule	0.087	0.100	0.077	0.120	0.096
HES Risk	0.130	0.200	0.154	0.160	0.161
Strategic Fit	0.522	0.400	0.462	0.480	0.466

The row average in Table 11 is the weight of the criteria based on pairwise comparison result. Strategic Fit has the highest weighting value of 0.466, followed by cost (0.277), HES risk (0.161) and schedule (0.096). This value will be multiplied with the value of respective attribute generated from direct rating method.

Consistency Test

An important consideration in term of the quality of the ultimate decision relates to the consistency of judgments that the decision makers demonstrated during the pairwise comparison process.

AHP provides a measure of this consistency of pairwise comparison judgments by computing the consistency ratio. The ratio is designed in such way that values of the ratio exceeding 0.1 are the indication of inconsistent judgments. Based on above consistency test result, the pairwise comparison of the criteria has acceptable degree of consistency. Hence the priority formulation can be continued.

Formulation

To prioritize housing renovation list, the Attribute Rating (AR) from SMART method and the Weight of Criteria (WOC) from AHP should be combined into a single formulation. The attribute rating of a criterion is multiplied with the weight of respective criterion, resulting a certain number of score. Each asset will have four different score for each criterion. These scores will be summed into a total score. The total score will be classified into some ranges, which reflect the priority result.

$$AR_{cost} \times WOC_{cost} + AR_{schedule} \times WOC_{schedule} + AR_{HES\ RISK}\ WOC_{HES\ RISK} + AR_{Strategicfit} WOC_{strategic\ fit} = Total\ Score$$

To align with the direct rating method, the classification of the total score will also use the linear method. The higher score will be assigned lower number of priority, means that the asset is more important to be renovated. Meanwhile, the lower score will be assigned with higher number of priority, means that the asset is less important. Table 12 shows the classification of the priority.

Table12
Priority Classification

Total Score Range	Priority
y≤50	5
50<y≤60	4
60<y≤70	3
70<y≤80	2
y>80	1

For example, there is an asset with strategic level 0 and HES risk level medium. Its renovation work can be completed in 6 months with total cost between US$ 5,000 – 10,000. By using Table 6 and 7, the AR for cost, schedule, HES risk and strategic fit are 75, 50, 50, 100 respectively. These numbers will then be multiplied each with the weight of respective criterion shown in Table 12.

75 x 0.277 + 50 x 0.096 + 50 x 0.161 + 100 x 0.466 = 80.23

Based on above calculation, the total score will then be reviewed by using Table 12. With the total score of 80.23, the asset (vacant house) will be assigned with Priority 1.

Housing Assignment Process

Similar with housing renovation process, following steps are the step by step taken in the housing assignment process that will help FMS team in prioritizing which housing requests need to be assigned in relation with limited number of vacant houses.

Criteria Selection

To generate list of housing assignment, FMS team sorts the requests based on its housing points. Originally there are three factors identified in the current process: Salary Class, Service Duration and Moving Type. During criteria selectin process with the SMEs, team also identified one important factor: Performance, to be included in the formula.

Criteria Analysis

Similar with Housing Renovation, in this step, team determined the attributes for each criterion which refers to the existing prioritization tool.

- Salary Class: It represents PSG level of the employee. In IEC, PSG ranges from 10 to 30. Higher PSG will contribute higher housing points.
- Service Duration: It represents length of time an employee has worked in the company. The longer the service duration, the higher points received by the employee. For this criterion, the range of attributes has been set up the same with the company's service award range.
- Moving Type

  In term of moving type, there are four attributes listed in the current process. They are Inter Region (> 200 km), Inter District (5 – 200 km), Within District (< 5 km). In the new prioritization tool, an important change in housing policy is included, i.e. no within district moving is

allowed, except for HES reason and for newly married / new hire employees that will be tagged as New Request. This change is expected to reduce backlog in the housing assignment list.

- Performance: It refers to employee achievement result on last year. An employee with above-average performance will get higher points compare with the average and below-average ones.

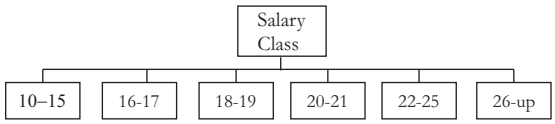

Figure15. Attributes for Salary Class

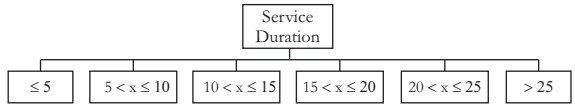

Figure 16. Attributes for Service Duration

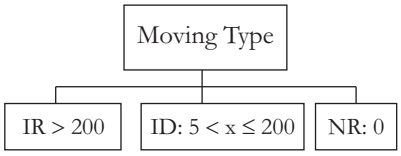

Figure17. Attributes for Moving Type

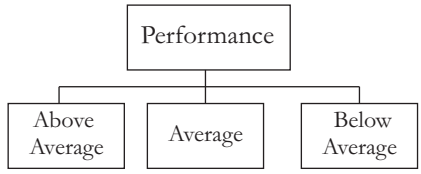

Figure 18. Attributes for Performance

Direct Rating

The value given to each attribute in salary class, service duration, moving type and performance criteria are shown in Table 13 and Table 14.

Table 13
Direct Rating for Salary Class and Service Duration Criteria

	Criteria		
	Salary Class	Service Duration (years)	Value
Attribute	10 – 15	< 5	50
	16 – 17	5 < x ≤ 10	60
	18 – 19	10 < x ≤ 15	70
	20 – 21	15 < x ≤ 20	80
	22 – 25	20 < x ≤ 25	90
	26 and up	> 25	100

Table 14.
Direct Rating for Moving Type and Performance Criteria

	Criteria		
	Salary Class	Service Duration (years)	Value
Attribute	0 km	Below Average	33
	5 – 200 km	Average	66
	> 200 km	Above - Average	100

Pairwise Comparison

Following table shows the discussion result of pairwise comparison for all criteria in Housing Assignment process. Similar with Housing Renovation, this result was agreed by all participants in FGD session.

Table 15
Criteria Pairwise Comparison – Agreed Result

No	Question	Degree of Importance	Scale
1	How importance is salary class to service duration?	Slightly more important	2
2	How importance is salary class to moving type?	Slightly less important	1/2
3	How importance is salary class to performance?	Slightly more important	2
4	How importance is service duration to salary class?	Slightly less important	1/2
5	How importance is service duration to moving type?	Moderately less important	1/3
6	How importance is service duration to performance?	Equal important	1
7	How importance is moving type to salary class?	Slightly more important	2
8	How importance is moving type to service duration?	Moderately more important	3
9	How importance is moving type to performance?	Moderately more important	3
10	How importance is performance to salary class?	Slightly less important	1/2
11	How importance is performance to service duration?	Equal important	1
12	How importance is performance to moving type?	Moderately less important	1/3

Synthesizing

By following the same process with Housing Renovation, the row average for Housing Assignment can be seen in Table 16.

Table 16
Synthesizing – Step

Criteria	Salary Class	Service Duration	Moving Type	Performance	Row Average
Salary Class	0.250	0.286	0.231	0.286	0.263
Service Duration	0.125	0.143	0.154	0.143	0.141
Moving Type	0.500	0.429	0.462	0.429	0.455
Performance	0.125	0.143	0.154	0.143	0.141

The row average in Table 16 is the weight of the criteria based on pairwise comparison result. Moving type has the highest weighting value of 0.455, followed by salary class (0.263) and service duration / performance (0.141). This value will be multiplied with the value of respective attribute generated from direct rating method.

Consistency Test

Based on above consistency test result, the pairwise comparison of the criteria for housing assignment has also acceptable degree of consistency. Hence the priority formulation can be continued.

Formulation

To prioritize housing assignment list, following formula will be used to classify the priority result.

AR_SC×WOC_SC+AR_SD×WOC_SD+AR_MT×WOC_MT+AR_PF×WOC_PF= Total Score

For example, there is a housing request from Jakarta based employee with PSG 22, service duration between 15-20 years and last year performance rating was Average. By using Table 13 and Table 14, the AR for salary class, service duration, moving type and performance are 9080, 100, 66 respectively. These numbers will then be multiplied each with the weight of respective criterion shown in Table 16.

90 x 0.263 + 80x0.141 + 100 x 0.455 + 66 x 0.141 = 89.76

Higher total score (i.e. 89.76) for an employee means that he/she has the right to choose his/her housing preference earlier than other employees with lower score, in the same housing cluster.

Prioritization Tools

Collaboration of both prioritization tools for housing renovation and housing assignment processes are expected to reduce the backlogs in housing assignment list. By having prioritization tool in housing renovation, FMM team has 72 vacant houses as Priority 1 to be renovated.

In the same time, by implementing new housing policy and having prioritization tool in housing assignment process, FMS team has 33 housing requests in their list.

Step 2: Select the best solutions

Following table shows the improvement action plan to be completed by the project team prior to move to Control phase. It also highlights the recommended solution for this research, such as develop prioritization tool, update SOP and company policy, and conduct proper socialization process.

Step 3: Implement chosen solutions

At the end of the Improve phase, team continuously collected and analyzed the performance result during the implementation of improved process. After completed all action plans and achieved zero backlog, team conducted a toll gate meeting. Toll gate meeting is a meeting between the Project Facilitator, Project Champion and LSS Advisor to determine whether a project can be formally declared into a Control phase. In this meeting, Project Facilitator will present the project since Define till the end of Improve phase, as well as showing the result. This project was successfully declared move to Control phase on June 2016.

Control Phase

Once the project is in Control phase, team continues to monitor the project result for 12 months before the project is set to Complete formally in the online LSS Project Tracking Database. A system for monitoring the project result is called Control Plan. The Control Plan is used to formalize the improved process with main objective to sustain the improvement after the project team has concluded its work and handed over the accountability to the process owner. The document must be completed by the Project Champion and Facilitator when moving the project into the Control phase. During the first 10 months in Control phase since June 2015, this project delivered the following result:

Table 17
Improvement Action Plan

No	Action Plan	Person In Charge	Due Date
1	Assigned dedicated person to manage housing provision process and act liaison between FMS/FMM team	FM AO Manager	1-March-2016
2	Conduct Update Meeting with Sponsor and Champion	Facilitator	1st Week of March 2016
3	Conduct Update Meeting with Labor Union	HR IR / Project Team	1st Week of March 2016
4	Develop prioritization tool for Housing Assignment	Project Team	2nd Week of March 2016
5	Develop prioritization tool for Housing Renovation	Project Team	2nd Week of March 2016
6	Revise SOP for Housing Selection	Team Member – FMS team	2nd Week of March 2016
7	Conduct socialization to all FMS and FMM teams	FMS / FMM Team Leaders	1st Week of April 2016
8	Update IRM / Company Policy by capturing changes listed in Table 6	HR IR	1-April-2016
9	Conduct socialization roadshow to all employees	HR IR / FM WO Manager / Project Team	4th Week of April 2016

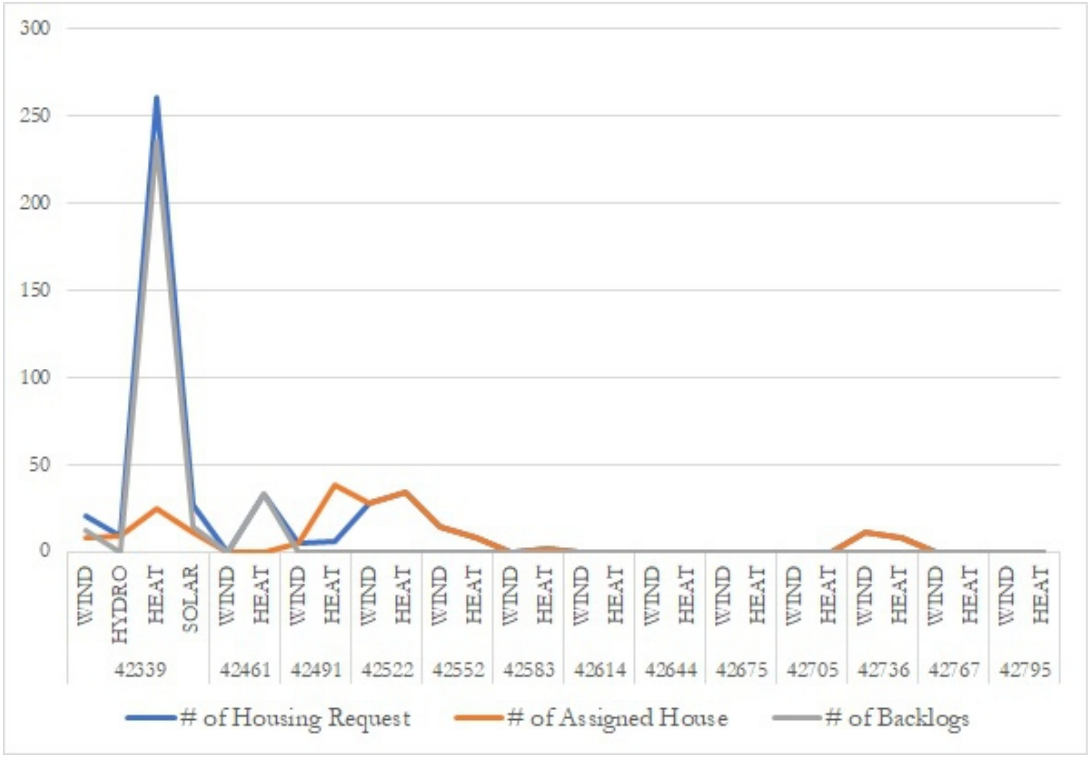

Figure 19. Control Plan After Improvement

Generally, SMART and AHP methods are used separately in many researches to prioritize few alternatives. In this research, combination of SMART and AHP is used to prioritize unlimited alternatives in housing renovation and housing assignment processes. The prioritization of housing asset and assignee allows the company to focus on available resources on the top priorities. These findings support previous research work done by Kasie (2013) and Victor (2016). The advantages of this mixed approach are listed below:

- SMART is simple, transparent and adaptable to multi background opportunities.
- AHP is applicable for group decision making environment. It allows use of qualitative as well as quantitative criteria and easy for pairwise comparison of criteria. Limitation of AHP in comparing all the alternatives and assigning different priority number will be resolved by using Direct Rating of SMART.

Findings from the analysis have responded the research question and had significant implication for overall housing provision process. However, during this research, author found that there is an opportunity to improve cycle time in housing renovation process. This research can be addressed by using Lean and Six Sigma methodologies that can reduce waste and variance in the process, with objective to complete housing renovation process in faster time.

Conclusion

The collaboration of DMAIC and Decision Analysis methodologies is doable and applicable to be implemented in many business processes. DMAIC is very powerful for process improvement while combination of SMART and AHP methodologies enables the decision maker(s) in developing priorities. Define phase is the most crucial step in doing a DMAIC project, since this will put a strong base for the project team to move forward.

Early engagement to Champion and Sponsor is important and their leadership behavior is a must for a successful project. Measure phase is intended to measure the actual process performance. Process mapping is very useful for identifying detail process that has multiple activities. Analyze phase is the core process where the project team investigate the problem using the data. It is important to have all the project members involved and make every process visible. It is important to involve management in implementation plan to empower the change. Combination of SMART and AHP can be used in decision analysis to prioritize unlimited alternatives. Pairwise comparison of criteria in AHP is getting complicated, when the number of the objects compared is increasing. This limitation can be resolved by determining weight in SMART.

References

Al-Harbi, K. (2001). Application of the AHP in Project Management, *International Journal of Project Management*, 19(2001), 19-27

Anchanga, P. (2006). Critical success factor for lean implementation within SMEs, *Journal of Manufacturing Technology Management*, 17(4), 11.

Avila, P., Mota, A., Putnik, G., Costa, L., Pires, A., Bastos, J. & Cruz-Cunha, M.M. (2015). Proposal of an empirical model for suppliers selection. *International Journal for Quality Research*, 9(1), 107-122.

Barsalou, M. A. (2015). *Root cause analysis: a step-by-step guide to using the right tool at the right time*, Florida, USA: CRC Press.

Breyfogle, F. (2004). Featured company bechtel. *ASQ Six Sigma Discussion Magazine*, 3(1), 4-6.

Chakrabortty, R., Biswas, T. & Ahmed, I. (2013). Reducing process variability by using dmaic model: a case study in Bangladesh. *International Journal for Quality Research*, 7(1), 127-140.

Creswell, J. (2014). *Research design: qualitative, quantitative and mixed methods approaches*. 4th edition. California: Sage.

Franchetti, M. J. (2015). *Lean six sigma for engineers and managers*. Florida, USA: CRC Press.

Filho, Adiel T. de Almeida, Cavalcante, Cristiano A.V., & da Costa, Ana Paula C.S. (2005). Multi criteria decision making on selection of decision analysis software. *Journal of Academy of Business and Economics*, 5. np.

George, M., Rowlands, D., Price, M. & Maxey, J. (2005). *Lean six sigma pocket tool book*. USA, McGraw-Hill.

George, M. (2010). *The Lean Six sigma guide to doing more with less*. New Jersey, USA: John Wiley & Sons.

Goodwin, P & Wright, G. (2009). *Decision analysis for management judgment*. UK: John Wiley & Sons.

Hariandja, B. (2016). Strategy selection to reduce work order active in maintenance team using SMART method. *International Conference on Ethics of Business, Economics and Social Science*, 163-173.

Horel, H. (2001). Putting six sigma in prospective. *Quality Engineering Magazine*, 40(10), 58-62.

Indonesia Energy Company. (2011). *Housing policy*. Unpublished manuscript.

Indonesia Energy Company. (2012). *Lean sigma champion training*. Unpublish manuscript.

Indonesia Energy Company. (2014). *Lean sigma green belt*. Unpublish manuscript.

Indonesia Energy Company. (2015). *West Operation – Camp Overview*. Unpublished manuscript.

Kasie, F.M. (2013). Combining simple multiple attribute rating technique and analytic hierarchy process for designing multi-criteria performance measurement framework. *Global Journal for Researches in Engineering*, 13(1), 14-30.

Kim Yong, Kim Jeong & Chung Min Gyo. (2010). A Six sigma-based method to renovate information services: focusing on information acquisition process. *Library Hi Tech*, 28(4), 632-647.

Kravchenko, T. & Seredenko, N. (2011). Decision making with modeling of problem situation using the analytic network hierarchy process. *International Journal of the Analytic Hierarchy Process*, 3(1), 28-45.

Kusnadi, A. & Yudoko, G. (2016). Contractor work preparation process improvement using lean six sigma: a case study of a global oil and gas company in Indonesia. *The South East Asian Journal of Management*, 10(1), 1-29.

Kumar, D. (2006). Six sigma best practices, US: J. Ross Publishing.

Pojasek, R. B. (2000). Asking "Why?" five times. *Environment Quality Management*, 10(1), 79.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal Services Sciences*, 1(1), 83-98.

Sehgal, S. & Kaushish, D. (2015). A State of art of review of DMAIC approach. *International Journal of Science and Research*, 4(8), 450-452.

Sharma, U. (2003). Implementing lean principles with the six sigma advantage: how a battery company realized significant improvements. *Journal of Operational Excellence*, 22(3), 9.

Singh, Harpreet & Lal, Harvinder. (2016). Application of DMAIC technique in a manufacturing industry for improving process performance – a case study. *International Journal on Emerging Technologies*, 7(2), 36-38.

Snee, R. (2000). Impact of six sigma on quality technology. *Journal of Quality Technology*, 12(1), 2-5.

Svinicki, M. D. (2010). *A guidebook on conceptual frameworks for research in engineering education*, N.p., n.p.

Thomas, A., Barton, R., & Okafor, C. C. (2009). Applying Lean six sigma in a small engineering company – a model for change. *Journal of Manufacturing Technology Management*, 20(1), 16.

Vachnadze, R. (2016). Prioritization of performance measures using analytic hierarchy process. *International Journal of the Analytic Hierarchy Process*, 8(3), 490-501.

Victor, B. (2016). New opportunity prioritization tool to reduce opportunity backlog in low oil price environment using combination of smart and ahp methods. [Unpublished master's thesis]. Institut Teknologi Bandung, Bandung.

Vorley, G. (2008). *Mini guide to root cause analysis*, UK: Quality Management & Training Limited.