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THE EFFECTS OF HYBRID RESOURCES AND INTERACTION PATTERNS ON RENEWABLE-ENERGY MANAGEMENT IN REMOTE AREAS

混合資源和相互作用模式對邊遠地區可再生能源管理的影響

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Abstract

This article describes a new method for developing renewable-energy management based on Common Pool Resources and Structural Equation Modeling that enables us to measure and validate variables using Confirmatory Factor Analysis (partial and full models). As an example, this new method was applied to the concept of micro-hydro development in the form of hybrid renewable energy management in Ambapa village. Results of Full model measurements show that the constructs of Hybrid Resources, interaction patterns, and outcomes have each other's positive and significant relationships and are valid against each of the expression variables since all the calculated outcome values meet the criteria of Critical Ratio ≥ 1.96 or Probability ≤ 0.005 and Standardized Factor Loading ≥ 0.5. The results of the full model showed that the path-coefficient values of hybrid resources to outcome referring to a ratio or significance of 2.680 and interaction pattern to outcome of 5.222 are positive and significant. The full model also fulfills the value of Goodness of Fit. Interaction patterns, which had a path coefficient of 0.478, were more dominant than hybrid resources, which had a path coefficient of 0.235. This new method is very effective in determining the impact of indicators to construct, and the effect of an exogenous construct to endogenous construct in develop of micro-hydro as hybrid resources and can be used to develop a program of micro-hydro to manage hybrid renewable energy in remote areas.

Keywords: Hybrid Resources, Interaction Pattern, Outcome, Goodness of Fit, Confirmatory Factor Analysis, Common Pool Resources, Standardized Factor Loading

摘要本文介紹了一種基於公共資源庫和結構方程模型開發可再生能源管理的新方法，該方法使我們能夠使用確認性因子分析（部分模型和完整模型）來測量和驗證變量。例如，這種新方法以安巴帕村混合可再生能源管理的形式應用於微水電開發的概念。完整模型測量的結果表明，混合資源，交互模式和結果的構造具有彼此的正向和顯著關係，並且對每個表達變量均有效，因為所有

計算出的結果值均滿足臨界比率≥1.96或概率的標準≤0.005，標準因子載荷≥0.5。完整模型的結果表明，混合資源與結果的路徑係數值是2.680，比率或顯著性以及交互方式與結果5.222是正向且顯著的。完整模型還具有擬合優度的價值。路徑模式為0.478的交互模式比路徑模式為0.235的混合資源更佔優勢。這種新方法對於確定構建指標的影響以及在微水作為混合資源開發中外源構建對內源構建的影響非常有效，可用於開發微水管理混合可再生能源的計劃偏遠地區的能源。

关键词： 混合資源，交互模式，結果，擬合優度，驗證性因子分析，公共資源池，標準化因子加載

I. INTRODUCTION

In general, micro-hydro resources in remote areas can only operate normally during the rainy season due to various technical reasons, such as: unstable voltage, frequent outages, lamp flicker, etc [1]. Consequently, the provision of electrical energy not only depends on water resources but also on other primary energy sources that can be converted into electrical energy, such as alternative solutions that can be a mix of microhydro and photovoltaic. Alternative solutions proposed by other authors can be applied in overcoming water discharge limitations during long dry seasons in remote villages [2], [3]. However, even if such resources are available, satisfactory results may not be attained if the outcomes for the community are not assessed. Electrical resources that have no outcome for the user's community will be a fruitless project of resource building and will experience failure and unsustainable. In the Common Pool Resources (CPR) method [4], [5], a relationship between resources and hybrid resources and outcomes is implicitly assumed but previous research, this approach has never been applied to hybrid resources that affect the societal outcomes. The use of hybrid resources in managing micro-hydropower plants does not only affect the outcomes, but is also affected by community interaction.

The CPR framework cannot currently be applied to the management of micro-hydro power plants especially for hybrid resources. Therefore, modification of the framework modifications [4], [6] is needed. Therefore, prior to its adoption, it is important to modify the infrastructure into hybrid resources. Nonetheless, the CPR method is still very complex due to the use of limited variables, which cannot simultaneously describe the correlations and interactions among all influential factors. To overcome these shortcomings, as a part of this study, a management model specifically aimed at hybrid resources (development of resources) was developed, based on the assumption that the community's interaction patterns influence the outcomes. The model was statistically and inferentially tested to ensure that it is valid and reliable, as well as capable of explaining the relationship between the exogenous and endogenous constructs.

A. Development of Micro-hydro as Hybrid Resources

Hybrid resources comprise of two or more resources and are increasingly being used to supply electrical energy [7], [8]. A hybrid is a mixture of two or more sources to cover each other's weaknesses, as an example of a mixture of micro-hydro and photovoltaic resources that can supply reliable electrical power. For example, micro-hydro resources can be used to ensure more reliable electricity supply [1], [9], [10]. As the value of hybrid resources cannot be measured directly, it is necessary to determine appropriate indicators. The determinant of the appropriate indicators is a tangible magnitude that has a very strong relationship and influence to a variable. Hybrid resources are the "development" of micro-hydro resources as resource mix of micro-hydro and photovoltaic, so that hybrid resources can be used as a variable of the model.In this study, in accordance with the CPR methodology [11], the CFA method [12] is applied, which consists of several manifest variables.

The Hybrid Resources Variable Model are influenced by dimensions PS and PE and formed by:

PS: indicators PS1, PS2, PS3 and PS4;

PE: Indicators PE1, PE2, PE3, PE4;

The Interaction Pattern Variable Model is influenced by dimensions KS and KM and formed by:

KS: indicators KS1, KS2, KS3, KS4, KS5, and KS6;

KM: indicators The KM1, KM31, KM3, and KM4;

The Outcome Variable Model is influenced by dimensions MB, MF and MK and formed by:

MB: Indicators MB1, MB2, MB3, MB4, MB5 and MB6;

MF: Indicators MF1, MF2, MF3, MF4, MF5 and M6;

MK: Indicators MK1, MK2, MK3 and MK4

(Figures 1, 2 and 3).

As shown in Figure 1, hybrid resources are is the development of resources to be a mix of microhydro and photovoltaic, so that the resource mix continues to supply energy despite the long dry season (PS1). During long dry seasons, the water debit decreases, thereby reducing the energy supply. Similarly, the intensity of sunlight decreases in cloudy weather, due to which the energy generated by the solar module is insufficient for charging the battery (PS2). Weather conditions also affect the sustainability of the local forests [13] and their capacity for maintaining adequate water discharge levels (PS3), so water is capable of moving water turbine. Sustainability of the local forests is the dominant indicator of hybrid resources construct. On the other hand, Hybrid resources tend to increase energy reserves because resources also increase (PS4). In this regard, reliance on hybrid resources is appropriate in maintaining a sustainable energy supply. However, for their most efficient use, it is necessary to limit the energy utilization by consumers (PE1) and classification of consumers (PE2) is a classification of user communities based on energy consumption of one of the construct of hybrid resources. According to the available evidence, these efforts tend to increase the electricity energy contributions [14] without exceeding the stipulated monthly electricity tariffs (PE3) [15], [16]. When the voltage and frequency is stable or normal and does not blink even though peak loads occur at night (PE4), consumers can pay their electricity bills every month smoothly and on time.

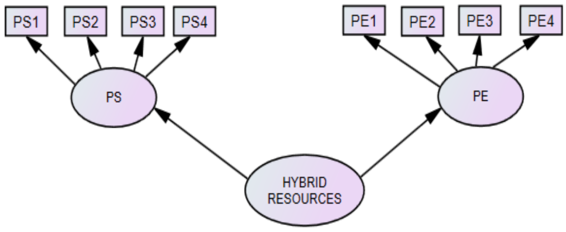

Figure 1. Model estimation of hybrid resources

B. Interaction Pattern

An interaction pattern is a form of partnership, communication, and attitude between the managers and the community in the management of an institution [17], such as the management of resources with cooperatives (KM1), distribution of energy to the local industry (KM2), and cooperation with electrical-equipment procurement companies (KM3) and local electrical contractors (KM4). Furthermore, communication can include information related to an electrical energy tariff (KS1), an annual meeting (KS2), and social use of electricity (KS3), the operating schedule of a hybrid-resources plant (KS4), the receiving of community suggestions (KS5), a decision regarding an electric energy tariff (KS6), or a problem-solving meeting (KS7).

The conditions apply to the physical characteristics of CPR, the characteristics of the community, the roles and positions of the participants, incentives, partnerships, information, communication, and other factors, which, as mentioned earlier, form the interaction patterns [4], and whether those managing CPR generally interact with each other in agreement or conflict greatly affects the level of management success. That construct model is the estimation of interaction patterns that influence institutional management, and the interaction pattern itself is the behaviour that is generated by the resource manager. The model of estimated interaction patterns can be seen in Figure 2.

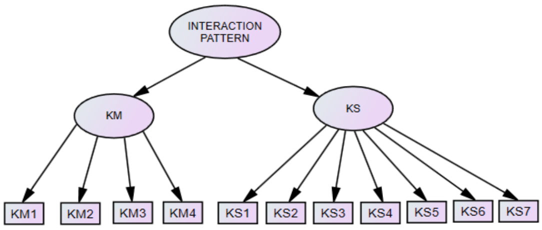

Figure 2. Model estimation of interaction pattern

Based on the IAD Framework methods [18], an interaction pattern can be developed that can be measured by the manifest variables by assessing the development of management partnerships in cooperation with the long-running cooperatives in the village and can always transport electrical energy into the local industry, in cooperation with the Electrical Appliance District and by partnering with local electrical entrepreneurs. In addition, the application of interaction patterns can be seen from the communication management of resources and electrical dues information, and by holding annual meetings, socialization of the way of electricity consumption, determining the schedule of operations and blackout, always receiving community advice, being able to establish electrical dues, and conducting deliberations in solving the problems of electrical management.

C. Outcome

The conception of outcome is the benefit that the user receives in fulfilling their life needs [3], such as the dimension of electrical energy benefits used in proportion to the obligation of electrical energy dues, financial benefits from community activities, and the provision of capital and public welfare [17], [19]. The outcome is a latent variable that cannot be measured directly, so the measurement of the manifest variable of the Outcome Variable is required for the Outcome Variable model estimate, as shown in Figure 3.

The utilization of electrical energy at night makes the time of community activity increase throughout the day (MB1), so that it can improve the quality of life (MB2). Community-managed production can be increased because it does not use the generator, set as a resource that has limitations. Community Knowledge Insight is increasing (MB3) with the presence of electronic news sources available 24 hours a day. Job aids no longer use manual labor to facilitate the work of the Community of Users (MB4), and in turn the Employment (MB5) and the Creativity of Society (MB6).

Good resource management will certainly impact the Benefits of Management (MF1) and Profit Partnership (MF2) [20]. Resource management based on the CPR principle leads to increased public income (MF3) because the profit gained is returned to the community in the form of working capital, community welfare savings, and village infrastructure development. With the benefits received by the public in the form of electrical energy, the community no longer uses a generator (MF4) in producing plantation (MF5), so the revenues increase and the value of land and rice fields increase as well (MF6).

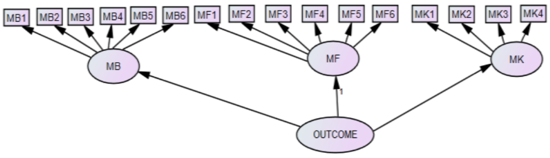

Figure 3. Model estimation of outcome

D. Operational Concept between Latent Variables

The operational concept of the Hybrid Resource constructs, Interaction Patterns, and Outcome show a causal relationship. Therefore, the Hybrid Resource Construct is correlated with the pattern of community interaction in influencing the outcome for the consumer. The causal relationship is shown in the full model estimation in Figure 4.

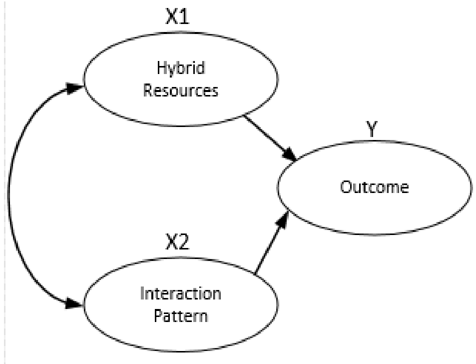

Figure 4. Full model estimation

Figure 4 shows that the Hybrid Resource correlates with the Interaction Pattern of the Outcome construct. This means that the Exogeneous Hybrid Resource and the Interaction Pattern construct influence the endogenous outcome.

Based on the operational concepts of the Hybrid Resource construct, Interaction, and Outcome Patterns, as well as the dimensions and manifest variables, the following research hypotheses can be made:

- The Hybrid Resources exogenous construct (X1) has a direct and significant effect on the Outcome endogenous construct (Y).
- The Interaction Pattern exogenous construct (X2) has a direct and significant effect on the Outcome endogenous construct (Y)

II. METHODS/MATERIALS

This is quantitative research with quantitative data used to further define the conceptual theory of the Institutional and Development Framework on CPR [5]. Research indicators were obtained by developing Mikrohidro resources as a Hybrid Resource correlation with the interaction patterns affecting the outcomes. This is holistic, complex, and dynamic research; therefore, the resulting issues are temporary for development in the data collection stage. Data were collected by quantifying all indicators of the respondent's choices of answers in the form of scores. The raw data is then tested for validation and reliability using the Statistical Package for Special Sciences (SPSS) program that generates results using hybrid resources, interaction patterns, and outcomes that are accurate and reliable. Data entry of each construct was analyzed using the Outler Model [24]. Furthermore, using the Analysis Moment of Structural (AMOS) application, 3 sets of construct fit models were produced, each affecting a significant and valid manifest variable.

The construct fit model is merged into a full causal connected model and tested using the

Inner Model. The results are an initial structural model, simultaneously interconnected with exogeneous and endogenous variables. The model is retested and examined using CFA analysis [12]. The results obtained are a structural fit model that can be used to analyze the relationship and the magnitude of influence between constructs and their influence on manifest variables.

A. Research Method

Data-1 was compiled qualitatively from resource site survey results, live interviews with managers, interviews with user communities, and HOMER simulation results from Hybrid Resources [2], [7], [8], [9] as a development of the Mikrohidro resource in the institutional CPR. Based on the IAD Framework methods [3], [4], [5], [11], [17], [21], the CPR infrastructure was modified as a grid of research instruments composed of several indicators or question materials in questionnaires. The respondent's answers were defined by values ranging from 1 to 5, according to the Likert method [22], and the questionnaire was distributed to 215 user communities to obtain data-2. The results of data -2 were processed and regulated using the SPSS application [22]. Analysis-1 was done by testing the feasibility and reliability of the data-2 set. Data-2 was tested as data entry and CPR infrastructure, and used as the entry model for input data from the application program AMOS [12], [23], [24]. Analysis-2 was conducted using a single CFA model to obtain a fit model depicting the direct influence between construct and dimensions, and indirect influence between construct and the manifest variables. Analysis-2 also used the full CFA model to obtain a Fit model depicting the direct influence of the exogenous construction of the endogenous and indirect between the manifest variables.

B. Instrument Grid of Research Variable

Based on the data collection results obtained from previous research [17], and [11], an instrument grid was arranged, and Data Collect Result, shown in Appendices 1, 2 and 3. Latent Construct consists of 2 sets of exogenous constructs and 1 set of endogenous constructs. These 7 dimensions comprise of 35 manifest statements.

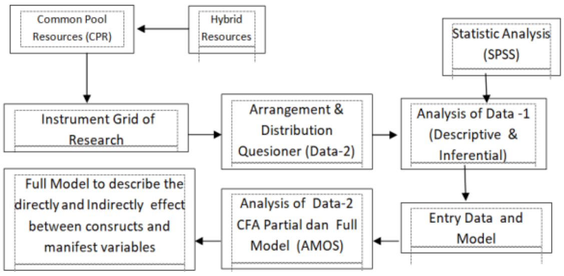

Figure 5. Research method

III. RESULTS AND DISCUSSION

A. Measurement Result of Manifest Variables

The data obtained through the questionnaire instrument are tested by analyzing the reliability and validity simultaneously using SPSS before measuring the model. In general, validity shows the results of the measurement of a questionnaire, while reliability is the consistency of the instruments used. Questions that fail to pass this test are deleted.

1) Validation Test of Variables

The validity test is used to measure the correlation coefficient between the score of a question or indicator tested with the total score on the variable [22]. The method used in this study is Corrected item-total correlation, where the validation results are determined in all question items. If r_{table} (0.13) is less than r_{count}, then the indicator is valid. The Hybrid Resource variable test results used to produce r_{count} of each manifest variable is greater than 0.13, and the PE4 variable is worth 0.129 (r_{count} <0.13); therefore, the PE4 variable is invalid. The Interaction Patterns produce valid variables KM2, KM4, KS3, and KS4 (r_{count}> 0.13). Meanwhile, KM1, KM3, KM5, KM6, KS5, KS6, and KS7 are invalid (rcount <0.13), therefore they are rejected. The results of the Variable Outcome test produce the r_{count} above 0.13 (all r_{count}> 0.13); therefore, all manifest variables are valid.

2) Reliability Test of Variables

The Reliability test is used to determine the consistency level of a questionnaire. This research used the Cronbach's Alpha method, with reliability accepted when the value is 0.6-0.79 of above 0.8 [22]. The result of testing manifest variable from the latent Hybrid Resource, Interaction Pattern, and Outcome yields produces Alpha values of 0.6 - 0.79. This means, all the manifest variable reliabilities are acceptable.

B. Measurement Result of Manifest Variables Effect to Construct in Partial Model

1) Measurement Model of Hybrid Resource and

Interaction Pattern Construct

According to Santoso [23], the Measurement Model is part of the SEM and consists of a latent (constructs), and several manifest variables (indicators) use to explain the relationship and the effect of the construct on its manifest variables. Tables 1 and 2 shows that the measurement model used in this research is partial, and estimation is carried out separately or on each exogenous construct derived from the Hybrid Resource, and Interaction Pattern constructs.

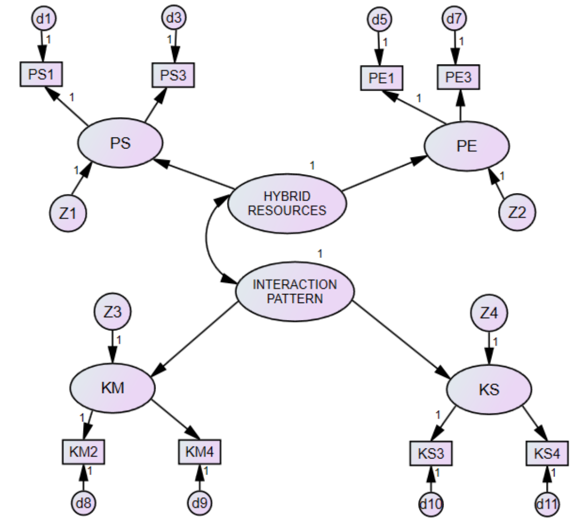

Figure 6. Initial model of exogenous construct

Figure 6 contains the AMOS application program with the final analysis results obtained measuring the model, as shown in Figure 7.

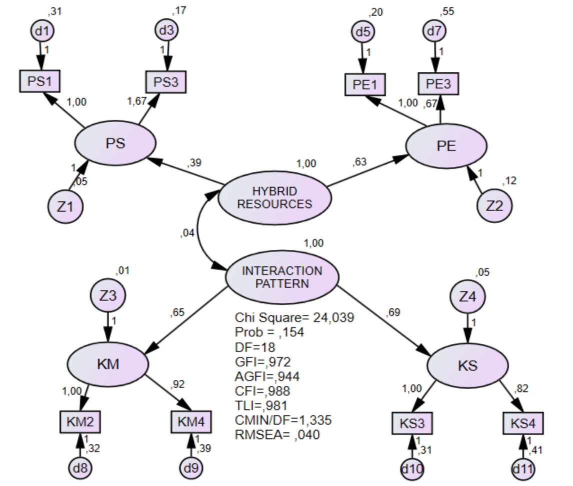

Figure 7. Fit model of exogenous construct

A measurement model is modified with the existence of variants and negative covariance. In the last result, no negative variants and covariates were found. Therefore, "testing" proceeded with the significance of the dimensions and indicators that reflect the validation of construct. The construct measurement model is accepted if the critical ratio (CR) ≥ 1.96 or probability (P) ≤ 0.005 and the loading factor standard (LFS) is ≥ 0.5 [3]. In contrast, the model is fit when the validation test is accepted with criteria values (chi square (24.039) ≤ 28.869, (P = 0.154)) ≥ 0.005, degree factor (DF = 18)> 0, goodness of fit index (GFI = 0.972) ≥0.9, adjusted goodness of fit index (AGFI = 0.944) ≥0.9, comparative fit index (CFI = 0.988) ≥0.95, Tucker-Lewis index (TLI = 0.981) ≥0.95, (CMIN / DF = 1.355) ≤2, root mean square error of approximation (RMSEA = 0.040) ≤0.08] [12]).

The test results show that all variable manifest indicators in the measurement model have a value of CR ≥ 1.96, (P = ***) ≤ 0.005 and LFS≥ 0.5. Therefore, the exogenous construct measurement model in figure 7 is acceptable, and the model is fit because most of the model validation test criteria have been met.

Table 1.
Test results of exogenous construct

Relationship between variables			C.R.	P
KM	<---	INTERACTION PATTERN	11.340	***
KS	<---	INTERACTION PATTERN	11.432	***
PE	<---	HYBRID_RESOURCES	9.367	***
PS	<---	HYBRID_RESOURCES	6.606	***
KM4	<---	KM	8.241	***
KM2	<---	KM		
KS4	<---	KS	8.470	***
KS3	<---	KS		
PE1	<---	PE		
PS3	<---	PS	7.098	***
PS1	<---	PS		
PE3	<---	PE	5.950	***

***≤ 0.001

2) Direct and Indirect Effects of Exogenous Construct on Manifest Variables

Table 2 shows that there are three dimensions that are directly affected and four manifest variables that are indirectly affected by the construct of hybrid resources, namely the direct effect on PS and PE while not directly affecting PS1, PS3, PE1, and PE3. The dimensions of PS directly affect the indicators PS1 and PS3, while the dimensions of PE directly affect the PE1and PE3. And there are 2 dimensions that are directly affected and 4 manifest variables that are indirectly affected by construct of Interaction Pattern, namely the direct effect on KS and KM while not directly affect KS3, KS4, KM2, and KM4. The dimensions of KS directly affect the indicators KS3 and KS4, while the dimensions of KM directly affect the KM2 and KM4.

Table 2.
Loading factor standard of exogenous construct

Relationship between variables			Estimate
KM	<---	INTERACTION PATTERN	0,994
KS	<---	INTERACTION PATTERN	0,951
PE	<---	HYBRID_RESOURCES	0,875
PS	<---	HYBRID_RESOURCES	0,866
KM4	<---	KM	0,696
KM2	<---	KM	0,757
KS4	<---	KS	0,678
KS3	<---	KS	0,791
PE1	<---	PE	0,848
PS3	<---	PS	0,878
PS1	<---	PS	0,629
PE3	<---	PE	0,543

Table 3.
Total effect of exogenous construct to manifest variables

Variable	Hybrid resources	Interaction pattern
PS	0.866[a]	0.000
PE	0.875[a]	0.000
KS	0.000	0.951[a]
KM	0.000	0.994[a]
PE3	0.476	0.000
PS1	0.544	0.000
PS3	0.761	0.000
PE1	0.743	0.000
KS3	0.000	0.752
KS4	0.000	0.644
KM2	0.000	0.753
KM4	0.000	0.691

[a] Direct effect

3) Measurement Model of Outcome Endogenous Construct

According to Santoso [23], the Measurement model is part of the SEM (Structural Eqution Model), which consists of a construct and several manifest variables used to explain their relationship and influence. The partial measurement model was used in this study

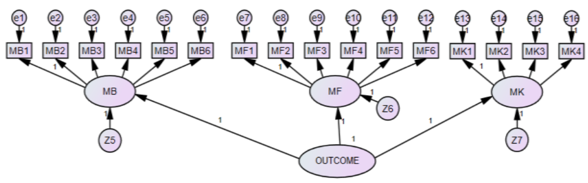

Figure 8. Initial model of endogenous construct

It was measured on each endogenous construct derived from the Outcome variable lattice instrument, as shown in Table 4.

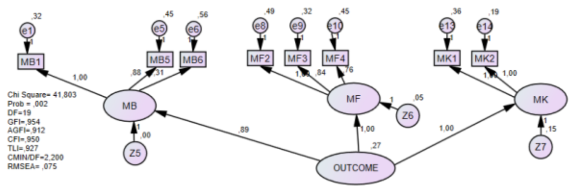

Figure 9. Fit model of endogenous construct

The initial model of the endogenous constructed in Figure 8 is the entry model of the AMOS application program. The results of the analysis obtained by the measurement model are shown in Figure 9. The measurement model is modified with the presence of variants and negative covariance. However, the result shows that no valuable negative variants and covariates were found. Therefore, this is followed by testing the significance of dimensions and manifest variables that reflect and validate the tests. If CR ≥ 1.96 or P ≤ 0.005 and LFS ≥ 0.5, the variable measurement model can be accepted, and the model is fit. The validation test is accepted with most of the criteria are met. [Chi Square (41.083) ≤ 30.143, (P = 0.002) ≥ 0.05, Degree Factor (DF = 19)> 0, Goodness of Fit Index (GFI = 0.954) ,90.9, Adjusted Goodness of Index (AGFI = 0.912) ≥0.9, Comparative Fit Index (CFI = 0.950) ≥0.95, Tucker-Lewis Index (TLI = 0.927) ≥0.95, (CMIN / DF = 2.2) ≤2, Root Mean Square Error of Approximation (RMSEA = 0.075) ≤0.08] [12].

Table 4.
Test result of endogenous construct

Relationship between variables			C.R.	P
MF	<---	OUTCOME		
MK	<---	OUTCOME		
MB	<---	OUTCOME	8.227	***
MF2	<---	MF		
MF3	<---	MF	8.390	***
MK2	<---	MK		
MB6	<---	MB	7.188	***
MB1	<---	MB		
MB5	<---	MB	6.045	***
MK1	<---	MK	8.904	***
MF4	<---	MF	6.740	***

All manifest variables in the measurement models of Tables 4 and 5 have CR values ≥ 1.96, (P = ***) <0.005 and LFS ≥ 0.5. Therefore, the Outcome measurement model in Figure 8 is acceptable, and the model is fit because the validation test criteria were met.

Table 5.
Loading factor standard of endogenous construct

Relationship between variables	Estimate

Relationship between variables			Estimate
MF	<---	OUTCOME	0.922
MK	<---	OUTCOME	0.803
MB	<---	OUTCOME	0.999
MF2	<---	MF	0.631
MF3	<---	MF	0.641
MK2	<---	MK	0.833
MB6	<---	MB	0.632
MB1	<---	MB	0.639
MB5	<---	MB	0.521
MK1	<---	MK	0.739
MF4	<---	MF	0.544

4) Direct and Indirect Effect of Outcome Constructs to Dimension and Manifest Variable

Table 6 shows that there are 3 dimensions and 8 indicators that are directly and indirectly affected by construct of Outcome. The direct effects are MB, MF and MK, while the indirect effects are MB1, MB5, MB6, MF2, MF3, MF4, MK1 and MK2. The dimensions of the MB directly affect the variables MB1, MB5 and MB6, the dimensions of MF directly influence the MF2, MF3 and MF4, while dimensions of the MK directly affect the variables MK1 and MK2.

C. Measurement Result of Exogenous to Endogenous Construct in Full Model

Figure 10 shows the Full Test Model, with the two constructs combined into a structural model consisting of the Hybrid Resource and the Interaction Pattern as the exogenous and outcome variables.

Previous research show that the Hybrid Resource and Interaction Pattern exogeneous construct is formed from 4 dimensions and 8 manifest variables that affect the Outcome endogenous construct which consists of 3 dimensions and 7 manifest variables.

Table 6.
Effect of endogenous construct to manifest variables

Variables	Outcome		
	Direct effect	Indirect effect	Total effect
MB	0.999	0.000	0.999
MK	0.803	0.000	0.803
MF	0.922	0.000	0.922
MF4	0.000	0.501	0.501
MB5	0.000	0.502	0.502
MB1	0.000	0.638	0.638
MB6	0.000	0.631	0.631
MK2	0.000	0.669	0.669
MK1	0.000	0.593	0.593
MF3	0.000	0.591	0.591
MF2	0.000	0.582	0.582

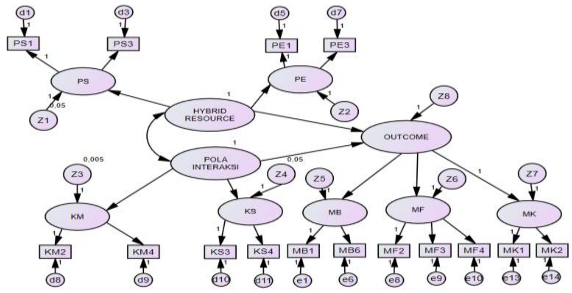

Figure 10. Initial of full model

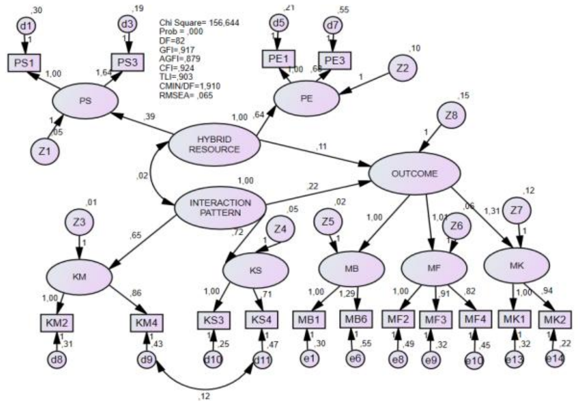

Figure 11. Fit full model

The effect of exogenous construct on endogenous constructs can be analyzed using the CFA Full Model. The effect of exogenous variables on endogenous results in an initial structural model as in Figure 10, which can be tested for significance, validation, and feasibility. The fit models in Figures 7 and 9 are combined into an entry data in the AMOS application program. The analysis results obtained Fit Full Model, as shown in Figure11 and Tables 7. This test consists of manifest variables that are not suitable. Therefore, MB 5 is removed, while the structure is modified with the presence of variants and negative covariance. In the end, no valuable negative variants and covariates were found. Therefore, it is continued by examining the significance of the dimensions and manifest variables that reflect the validation test of structural models with the criteria values being met. All manifest variables in the measurement model in Table 7 and 8 have CR values of 1.96, (P = ***) ≤ 0.005 and LFS>of 0.5. Therefore, the structural model in Figure 11 is acceptable, and the model is fit because most of the model validation test criteria have been met. [Chi Square (156.644) ≤ 104 (P = 0.000) ≥ 0.05, Degree Factor (DF = 82) > 0, Goodness of Fit Index (GFI = 0.917) ≥ 0.9, Adjusted Goodness of Index (AGFI = 0.879) ≥ 0.9, Comparative Fit Index (CFI = 0.924) ≥ 0.95, Tucker-Lewis Index (TLI = 0.903) ≥0.95, (CMIN / DF = 1.910) ≤2, Root Mean Square Error of Approximation (RMSEA = 0.065) ≤ 0.08] [12].

Table 7.
Test result of full model

Relationship between variable			C.R.	P
OUTCOME	<---	HYBRID_RESOURCES	2.680	0.007
OUTCOME	<---	INTERACTION_PATTERN	5.222	***
KM	<---	INTERACTION_PATTERN	11.404	***
KS	<---	INTERACTION_PATTERN	12.082	***
PE	<---	HYBRID_RESOURCES	9.691	***
PS	<---	HYBRID_RESOURCES	6.526	***
MB	<---	OUTCOME		
MF	<---	OUTCOME	6.325	***
MK	<---	OUTCOME	6.475	***
KM4	<---	KM	8.275	***
KM2	<---	KM		
KS3	<---	KS		
PE1	<---	PE		
PS3	<---	PS	7.133	***
PS1	<---	PS		
MB1	<---	MB		
MB6	<---	MB	7.002	***
MF2	<---	MF		
MK1	<---	MK		
MK2	<---	MK	9.404	***
PE3	<---	PE	6.088	***
KS4	<---	KS	7.980	***
MF3	<---	MF	6.607	***
MF4	<---	MF	5.686	***

Table 8.
Loading factor standard of full model

Relationship between variable			Estimate
OUTCOME	<---	HYBRID_RESOURCES	0.235
OUTCOME	<---	INTERACTION_PATTERN	0.478
KM	<---	INTERACTION_PATTERN	0.994
KS	<---	INTERACTION_PATTERN	0.955
PE	<---	HYBRID_RESOURCES	0.898
PS	<---	HYBRID_RESOURCE	0.867
MB	<---	OUTCOME	0.949
MF	<---	OUTCOME	0.879
MK	<---	OUTCOME	0.869
KM4	<---	KM	0.648
KM2	<---	KM	0.761
KS3	<---	KS	0.835
PE1	<---	PE	0.843
PS3	<---	PS	0.861
PS1	<---	PS	0.632
MB1	<---	MB	0.658
MB6	<---	MB	0.644
MF2	<---	MF	0.598
MK1	<---	MK	0.770
MK2	<---	MK	0.812
PE3	<---	PE	0.547
KS4	<---	KS	0.614
MF3	<---	MF	0.647
MF4	<---	MF	0.540

1) Direct and Indirect Effect of Exogenous to Endogenous Construct

Table 9 shows that 2 exogenous constructs are directly a endogenous construct. Exogenous construct of Hybrid Resources has a direct effect of 0.235 and the Interaction Pattern construct of 0.478 to the endogenous construct of Outcome. It can also be writen in structural equations [25]:

$$Y = 0.235X1 + 0.478X2 \tag{1}$$

where:
Y = Outcome endogenous construct
X1 = Hybrid Resources exogeneous construct
X2 = Interaction Pattern exogenous construct.

Figure 11 shows that the Hybrid Resources construct is directly 2 dimensions and indirectly 4 manifest variables, the Interaction Pattern construct is directly 2 dimensions and indirectly 4 manifest variables, the Outcome construct is directly 3 dimensions and indirectly 7 manifest variables. The direct effect on PS, PE, KM, KS, MB, MK and MF and does not directly affect PS1, PS3, PE1, PE3, KM2, KM4, KS3, KS4, MB1, MB6, MF2, MF3, MF4, MK1dan MK2. The PS dimension directly influences the PS1 and PS3 manifest variables. The PE dimension directly influences the PE1 and PE3 manifest variables. The KM dimension directly influences the KM2 and KM4 manifest variables, The MB dimension directly influences the MB1 and MB6 manifest variables, The MF dimension directly influences the MF2, MF3 and MF4 manifest variables, while the MK dimension directly influences MK1 dan MK2.

2) Hypothesis Test

The H1 hypothesis is acceptable because the Hybrid Resource exogenous construct directly and significantly influences the Outcome endogenous construct with a Critical Ratio value of 2.680 or (CR) $\geq$ 1.96 and Probability of 0.007 or (P) $\leq$ 0.005. The H1 hypothesis is accepted because the Interaction Pattern construct has a direct and significant effect on the Outcome endogenous construct with a Critical Ratio value of 5.220 or (CR) $\geq$ 1.96 and Probability of *** or (P) $\leq$ 0.005.

Table 9.
Total effect of exogenous to endogenous construct

Variables	Hybrid resources	Interaction pattern	Outcome
OUTCOME	0.235	0.478	0.000
MK	0.204	0.416	[a]0.869
MF	0.206	0.421	[a]0.879
MB	0.223	0.454	[a]0.949
PS	[a]0.867	0.000	0.000
PE	[a]0.898	0.000	0.000
KS	0.000	[a]0.955	0.000
KM	0.000	[a]0.994	0.000
MF4	0.111	0.227	0.475
MF3	0.134	0.272	0.569
MK2	0.166	0.338	0.706
MK1	0.157	0.320	0.670
MF2	0.123	0.252	0.526
MB6	0.143	0.292	0.611
MB1	0.147	0.299	0.625
PE3	0.491	0.000	0.000
PS1	0.548	0.000	0.000
PS3	0.746	0.000	0.000
PE1	0.757	0.000	0.000
KS3	0.000	0.798	0.000
KS4	0.000	0.586	0.000
KM2	0.000	0.756	0.000
KM4	0.000	0.645	0.000

D. Discussion

The results of the 2nd order CFA test of the Hybrid Resources construct and the Interaction Pattern toward Outcome are described as follows:

1) Effect of Hybrid Resources to Dimension of Resource Operation and Energy Consumption

Hybrid Resources proved to have a relationship to, an influence on, and a significance regarding the dimension of resource operations (PS); thus, they fulfilled the criteria. Hybrid Resources directly affected the 0.867 against the operation of the resources. This is reflected in the presence of a 0.548 influence of resource operations against the fixed power supply variable even though the river water discharge was reduced (PS1) and had an effect of 0.746 with forest sustainability (PS3). Thus, the variable sustainability of the forest remains influential and dominant in overcoming the power supply shortage the user community experienced even though the river water discharge had begun to decrease. Joint operation of water and photovoltaic resources aims to cover the shortcomings and weaknesses of each power supply in supplying electrical energy and "without stopping meeting the needs of the community". Similarly, the joint operation of the resources influenced by forest sustainability is an effort to maintain water resources by managing the continuity of the electrical energy supply of users in the dry season. This effort will surely overcome the shortage of water resources in the dry season. It will also make the forest preservation to reflect the most dominant indirect influence of construct hybrid resources in the development of micro-hydro Generator management as a hybrid resource.

Hybrid Resources proved to be related to, influential on, and significant regarding the dimensions of electrical energy consumption; thus, they fulfilled the criteria. Hybrid Resources directly affected 0.898 against the use of electrical energy (PE), which is reflected by the indirect influence of Hybrid Resources of 0.757 against the manifest variable of energy consumption restriction (PE1) and has an effect of 0.451 on the electric energy tariff manifest variable (PE3). This means that the restriction of energy consumption is of great impact and is crucial for anticipating whether excess or less energy is used compared to the increase in the electricity tariff. The energy restriction for any community of users will cause Hybrid Resources to work continuously without resource overloading. It will also make the energy restriction reflect the most dominant indirect influence of Hybrid Resources in developing Microhydro generator management as Hybrid Resources.

2) Effect of Interaction Pattern to Dimension of Cooperation and Communication

The interaction pattern has a relationship to, an influence on, and significance regarding the dimension of partnership (KM); thus, it fulfilled the criteria. The direct influential partnership amounted to 0.994 in partnership, which reflects the influence of the 0.756 partnership on the manifest variable of electrical energy distribution to the local industry (KM2) and the effect of 0.695 in cooperation with local entrepreneurs (KM4). The pattern of interaction is quite large and most dominant in channeling electrical energy to local industry in partnership compared with local entrepreneur cooperation. In this case, the unused energy in the form of excess production of electrical energy can be channeled to the needs of local industries. Thus, the transmission of electrical energy can be profitable managers and more flexible in regulating management in the long dry season. Therefore, the distribution of electrical energy to local industries reflects the most dominant indirect influence of the interaction pattern in the management of Microhydro power plants as Hybrid Resources.

The interaction pattern is proven to relate and direct and significant effect on the communication (KS) dimension and has fulfilled the criteria. The direct impact interaction pattern of 0.955 on communications (KS) is reflected by the indirect influence of the 0.798 interaction pattern against the presence of the electrical energy Tariffs (KS3), which has an effect of 0.586 with the delivery of the electrical resource operation Schedule (KS4). This means that the socialization of tariffs of electrical energy is of great influence and most dominant in communication compared with delivering the schedule of resource operations. In this case, transparency of electrical energy tariff components can further encourage the user community to more participate in the savings of electrical energy use and be aware of the obligation of payment of electricity dues on time. Therefore, the socialization of electricity tariffs is used as a reflection of the most dominant indirect influence of the interaction pattern in the management of Microhydro power plants as hybrid Resources. The interaction Pattern is proven to have a relationship and significant influence on the dimensions of Partnership (KM) with a direct effect of 0.994, which is reflected by 0.756. The manifest variable of channeling electricity to the local industry (KM2) has an effect of 0.695 with the local entrepreneur (KM4). The interaction pattern is quite large and the most dominant in channeling electrical energy to the local industry in partnership compared to the cooperation of local entrepreneurs. In this case, unused energy in the form of excess electricity production is channeled to the needs of local industries. Therefore, the distribution of electrical energy can increase management income and help limit management costs in the long dry season. This means that the distribution of electricity to the local industry is used as a reflection of the most dominant indirect effect of the Interaction Pattern in the management of micro-hydro powers as a Hybrid Resources.

3) Effect of Outcomes to Comparable, Financial, and Capital Benefits

The outcomes proved to have a direct and significant impact on the dimensions of benefits and compare costs and have fulfilled the value of the criteria. A direct effect of 0.949 on the benefits and comparable costs (MB) reflecting the indirect influence of the Outcome variable on the time of Co mmunity activity at night (MB1) of 0.625, and to the creative community of users (MB6) by 0.611. This means that the activity of people in the night has a more dominant direct influence on the benefits and costs comparable to the creativity of people in the night. The time of longer community activities at night causes the quality of resources, knowledge, and information as well as community productivity. Therefore, the Konstruk of the Outcome makes the time of the activity of users in the evening as a reflection of the indirect influence of the most dominant benefits and costs of the Outcome in the management of Microhydro power plants as hybrid Resources.

The outcomes proved to have a direct and significant impact on the dimensions of financial benefits and meet the value of criteria. The Outcome variable has a direct effect of 0.879 on the financial benefit (MF) reflecting the indirect influence of the Outcome of 0.526 on the manifest variables of the partnership benefit (MF2), impactful 0.569 on the increase of user community revenue (MF3), influential 0.475 on the fuel Use savings generator (MF4). This means that revenue increases have the strongest direct influence on the benefits of partnership and fuel consumption savings. The outcomes that users receive will increase the management’s revenue in the form of benefits accruing from managing the financial benefit, while also making the increase in public income a reflection of the most dominant indirect influence of the outcome of the management of microhydropower plants as hybrid resources.

The outcome has been proven to be related to and directly affect the dimensions of working capital and to have fulfilled the value of criteria. The Outcome effect directly increases the benefit of working capital by a magnitude of 0.869, benefits of working capital formed by the indicator with a magnitude of 0.670 the working capital of the village community [MK1], and the indicator with a magnitude of 0.706 savings of the user community [MK2] (See Figure 11). This means that the working capital directly affects the most dominant form of the community-saving efforts. The benefits gained by the manager are transferred to the user community in the form of savings, thereby improving the welfare of the community itself and making these savings a reflection of the indirect influence of the outcome on the management of microhydropower plants as hybrid resources.

4) The Effect of Exogenous Constructs of Hybrid Resources and Interaction Patterns on Endogenous Constructs of the Outcome

The results of the analysis obtained using structural equation (1) and the full model (Figure 11) reveal that the outcome construct was directly influenced by Hybrid Resource X1 and that Interaction Pattern X2 is reflected in each dimension and variable of its manifestation in renewable energy management in remote villages.

The constructs Hybrid Resource X1 and Interaction Pattern X2 simultaneously affect the construction of the Y outcomes, passing through the manifest variables MF3, MF4, MK1, MK2, MB1, and MB2. This means that the involvement of the interaction pattern as a construct has a significant influence on outcomes for the community compared to hybrid resources. Nevertheless, the hybrid resources construct still influences the outcome, even though it does not involve an interaction pattern. Similarly, the interaction pattern construct will still influence the outcome even if it does not involve a hybrid resources construct.

5) Comparison of the Previous Research Results

In accordance with previous research methods [3, 16], the CFA method was tested to compare the influence between constructs based on the appropriate CPR on the development model of micro-hydro resources. This was done because this method directly and indirectly reflects the relationship between latent constructs with manifest variables (indicators) [26]. The advantage of this method is that it can be used to test the estimation model with two or more variables that cannot be directly measured simultaneously. Furthermore, this method also involves all theoretical variables contained in the CPR infrastructure [20], is used to make insignificant estimation models [17], and helps to determine whether the influence between constructs and their manifest variables is valid, reliable, and simple in developing microhydropower resources using water and solar resources with limited river discharge in remote areas.

6) Recommendations and Implications of This Research

The results of this study can be used to determine the scale of development of microhydropower in response to hybrid resources priorities. The interaction pattern is the most dominant positive factor affecting outcomes in Ambapa Village, so developing management by setting priorities for the microhidro power plant as a hybrid resource is the most strategic means of increasing the outcome for the community. Therefore, the following actions are recommended for implementing a hybrid resource power management model:

- Imposing restrictions on the use of electricity to ensure a fair distribution of electrical energy and anticipate excess usage.
- Developing a forest and environmental conservation program and maintaining riverbanks and dams to ensure that water discharge remains sustainable.
- Developing a program to increase cooperation with local entrepreneurs, thus ensuring that the benefits and costs incurred by the community are comparable.
- Requiring managers to determine the increase in the amount of electrical energy contributions based on the increased benefits accruing to consumers through mutual agreement.
- Motivating consumers to conduct activities at night, so as to increase the productivity of community work.
- Ensuring that benefits obtained by the manager(s) from the distribution of electricity and local industry are provided in the form of welfare savings.

IV. Conclusion

Based on the analysis and statistical discussion of the influence of hybrid resources and interaction patterns for outcome variables on the management of microhydropower plants in remote areas and villages, the following conclusions can be drawn:

- The results of the full measurement model showed that the value of the path coefficient of the hybrid resources to the outcome was 2.680, and that of the path coefficient of the interaction pattern to the outcome was 5.222.
- The hybrid resources construct is a direct reflection of the dominant influence on the energy consumption (0.898) and the most dominant indirect influence on the manifest variable restrictions on the use of electrical energy by 0.757.
- The interaction pattern was the most dominant reflection on the direct influence of the partnership dimension (0.994) and the most dominant indirect effect on the manifest variable dissemination of the electricity rate (0.756).
- The outcome reflects the direct influence on the dimensions of benefits and comparable costs (0.949) and the most dominant indirect influence on the manifest variable activity at night (0.625). It also produces a structural equation of resource development, as the presence of hybrid resources explains that the exogenous construct of hybrid resources has an effect of 0.235 and an interaction pattern of 0.478 compared to endogenous construction outcomes. Equation (1) indicates that there will be outcomes for the community when the development of resources as hybrid resources does not involve an interaction pattern; however, the significance of such outcomes increases if the development of resources involves an interactive pattern of management and the community in managing the microhydropower plant as a hybrid resource.

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APPENDICES

Appendix 1.
Instrument grid and data collect result of hybrid resources construct

Exogenous construct	**Dimensions**	**Manifest statements**	**STS[a] (1)**	**TS[b] (2)**	**N[c] (3)**	**S[d] (4)**	**SS[e] (5)**
Hybrid resources (X)	Operation of resources (PS)	PS1	0	3	39	114	59
		PS2	0	5	53	87	70
		PS3	0	3	57	64	91
		PS4	0	1	59	75	80
	Energy consumption (PE)	PE1	0	3	51	63	99
		PE2	0	1	71	71	72
		PE3 PE4	0	4	61	56	94
			0	1	57	66	91

[a] STS = Very Disagree, [b] TS = Disagree, [c] N = Neutral, [d] S = Agree, [e] SS = Very Agree

Appendix 2.
Instrument grid and data collect result of interaction pattern construct

Endogeneous construct	**Dimensions**	**Manifest statements**	**[a]STS (1)**	**[b]TS (2)**	**[c]N (3)**	**[d]S (4)**	**[e]SS (5)**
Interaction Pattern (X2)	Coorperate (KM)	KM1			61	8	76
		KM2		7	88	6	54
		KM3		2	53	4	86
		KM4		7	101	2	59
	Communi cation (KS)	KS1		5	57	4	59
		KS2		2	72	4	67
		KS3		7	95	50	63
		KS4		1	85	55	74
		KS5			55	60	100
		KS6		1	69	74	71
		KS7			54	59	102

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Appendix 3.
Instrument grid and data collect result of outcome construct

Endogeneous construct	**Dimensions**	**Manifest statements**	**[a]STS (1)**	**[b]TS (2)**	**[c]N (3)**	**[d]S (4)**	**[e]SS (5)**
Outcome (Y)	Comparable Benefit and Cost (MB)	MB1		1	28	58	128
		MB2			41	72	102
		MB3		3	57	51	74
		MB4		4	54	71	89
		MB5		1	47	76	91
		MB6		13	67	52	83
	Financial Benefit (MF)	MF1		1	55	67	92
		MF2		4	63	65	83
		MF3			46	93	76
		MF4	1	3	27	53	151
		MF5			37	17	161
		MF6			32	23	160
	Capital and Property (MK)	MK1		6	48	49	112
		MK2		1	43	60	111
		MK3		9	61	63	82
		MK4	1	4	42	40	103