Power Supplier Recommender

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1 EXECUTIVE SUMMARY

Since 1 November 2018, the Open Electricity Market had been extended to all consumers across Singapore by zones. This initiative provided about 1.4 million households and business accounts with more choice and flexibility when buying electricity, while being provided with the same electricity supply through the national power grid.

This decision making task may seem confusing due to overwhelming number of different supplier and pricing plans. While a current model exists in the open market website, it is a supplier centric based on filtering technique to rank the different price plans according to the decision maker preferences. This requires the decision maker to understand the differences between the supplier price plans in terms of pricing, green energy etc. Our team, comprising of 6 Singaporeans from different age group and background hope to improve the model by making it more consumer centric where the model works on individual profile and preferences to arrive on the final recommendation. Leveraging on the diversity of the team, we redefined the rules according to individual preferences which did not exists in the current model to help us build the power supplier recommender model.

Using the techniques imparted to us in lectures, our group first set out to build a sizeable knowledge base via conducting an interview and administering a survey. While building the system, we downloaded the pricing information from the different power suppliers and transform it into a database, CLIPS to synthesize the rule based reasoning process, and Python to integrate it into an easy to use UI for the everyday user.

Our team had an exciting time working on this project, and hope to share our insights with everyone. There are truly are a wide array of individual factors to come to a final decision in the switch to a different pricing plan, and we only wish there was more time to work on the scope and scale of the project.

2 PROBLEM DESCRIPTION

2.1 PROJECT OBJECTIVE

Comparing the offers from the various energy retailers can be challenging. Currently at this website, https://compare.openelectricitymarket.sg/#/home, a potential consumer can enter some key inputs and he or she will receive the various offers. In general, there a numerous offer and it can be a rather daunting exercise in determining which offer is best suited to the consumer. A recommendation application that assists consumer in selecting the most appropriate offer from the various electricity retailers will certainly be very helpful.

Overview of Electricity Market

Since 2001, the Energy Market Authority (EMA) has gradually opened the retail electricity market to competition, allowing business consumers more options in managing their energy cost. Eligible consumers can choose to buy from a retailer at a price plan that best meet their needs or buy from the wholesale electricity market at the half-hourly wholesale electricity prices instead of buying from SP Group at the regulated tariff. Those who exercise this choice are termed as contestable consumers.

On 1 April 2018, EMA commenced the soft launch of Open Electricity Market, where households and businesses in Jurong can choose to buy electricity from a retailer at a price plan that best meets their needs. Subsequently, from 1 November 2018, the Open Electricity Market will be extended to all consumers across Singapore by zones. About 1.4 million households and business accounts will have more choice and flexibility when buying electricity, while being provided with the same electricity supply through the national power grid.

It is not compulsory for consumers to switch to a retailer. A consumer can remain with SP Group and buy electricity at the regulated tariff. There is also not deadline for switching. The nationwide launch of Open Electricity Market will be rolled out progressively in four geographical zones.

Zone	Postal Codes Starting With…	To be launched from*
1	58 – 78	1 November 2018
2	53 – 57, 79 – 80, 82 – 83	1 January 2019
3	34 – 52, 81	1 March 2019
4	01 – 33	1 May 2019

** Subject to changes. Visit www.openelectricitymarket.sg for the latest schedule. Consumers with postal codes starting with 60-64 were able to buy from a retailer since 1 April 2018.*

Figure 1: Open Electricity Market zones and their launch dates

With the current Open Electricity Market, a consumer has the choice of buying electricity from any of the following retailers at a price plan that best meets their needs:

1) Best Electricity Supply Pte Ltd
2) Environmental Solutions (Asia) Pte Ltd*
3) iSwitch Pte Ltd
4) Keppel Electric Pte Ltd
5) Ohm Energy Pte Ltd
6) PacificLight Energy Pte Ltd
7) Sembcorp Power Pte Ltd
8) Senoko Energy Supply Pte Ltd
9) Seraya Energy Pte Ltd
10) SingNet Pte Ltd*
11) Tuas Power Supply Pte Ltd
12) Union Power Pte Ltd*

Since there are several retailers that the household consumers can purchase electricity, the consumers will be spoilt with choices. Comparing the offers from these retailers can be challenging. Currently at this website, https://compare.openelectricitymarket.sg/#/home, a potential consumer can enter some key inputs and he or she will receive the various offers. In general, there a numerous offer and it can be rather daunting exercise in determining which offer is best suited to the consumer. The current application needs a 3 step procedure as illustrated below:

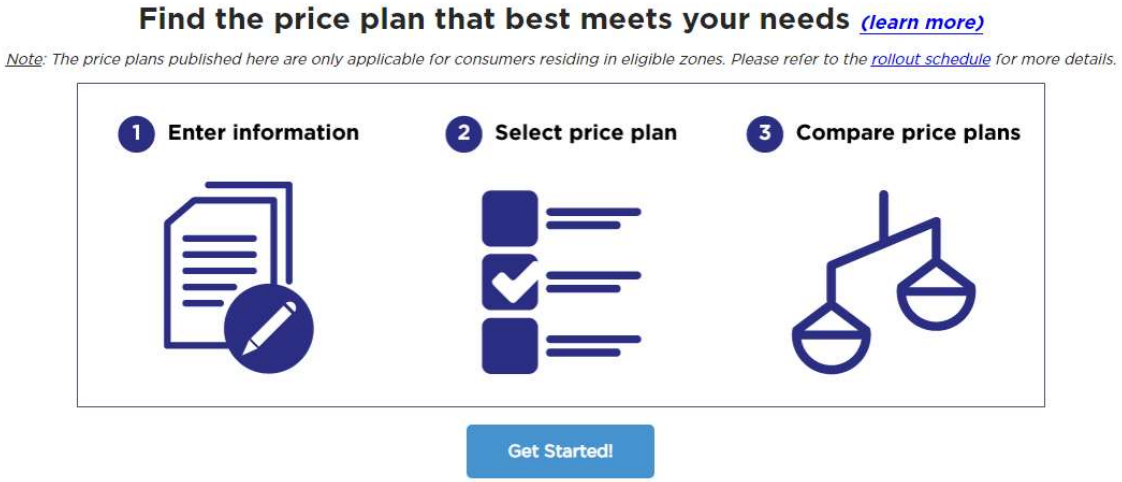

Figure 2: Three Step Procedure

Currently, the system will list two types of standard price plans:

1) Fixed Price Plans are more suitable for consumers who prefer a constant electricity rate throughout the contract duration. The electricity rate may be higher or lower than the regulated tariff during the contract duration, as the regulated tariff is reviewed every quarter.

2) Discount Off the Regulated Tariff Plans provide a fixed discount off the regulated tariff, but the electricity rates will change when the regulated tariff changes. These plans are more suitable for consumers who do not mind changes in electricity rates every quarter so long as it is lower than the regulated tariff.

Based on some basic inputs, the existing Price Comparison website will list a table of offers which is still challenging for a consumer to select the best offer. The application will list all possible offers based on available contract periods, but the number of offers generated can be numerous. Nevertheless, you can also make comparison of the offers based on a maximum of any of the 3 offers at the time. Selecting these 3 best offers is also a challenge since the consumers are also advised to read the respective price plan's Fact Sheet by downloading from the respective offers.

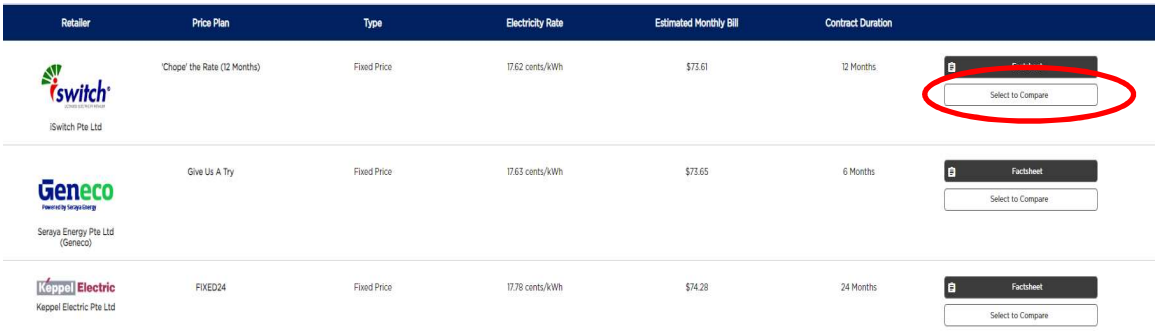

Figure 3: List of Retailers

At the start, the consumer needs to select the appropriate consumer type, either residential or business. The residential consumer type can be any of the following which the consumer can choose the appropriate type:

1) HDB 1-Room
2) HDB 2-Room
3) HDB 3-Room
4) HDB 4-Room
5) HDB 5-Room
6) HDB Executive
7) Apartment
8) Terrace
9) Semi-Detached
10) Bungalow

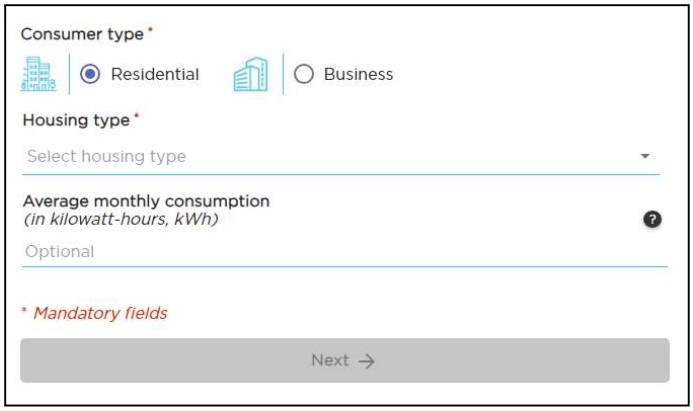

Figure 4: Input form to select Consumer type and Housing type

Factors critical in the selection of the preferred offer are as follows but not limited to the following:

1) Risk appetite
2) Belief on whether the SP tariff rate will remain unchanged, increase or decrease
3) Short term rental or long term
4) Estimated monthly Electricity Bill – larger the saving higher the risk appetite
5) One time registration fee
6) Late payment charges
7) Early termination
8) Security deposit
9) Other fees and charges
10) Green power
11) Bundled offer
12) Incentives
13) Smart meter
14) Direct billing
15) Other factors – will different residential type be influence differently by the offer? To investigate.

3 KNOWLEDGE MODELLING

Knowledge modeling can be decomposed into three main stages (Schreiber, et al., 2001),

(i) Knowledge identification
(ii) Knowledge specification
(iii) Knowledge refinement

Various activities are carried out during each of these stages and the crux of model construction lies in (ii) Knowledge specification.

3.1 KNOWLEDGE IDENTIFICATION

Knowledge identification sets the groundwork for the next stage encompassing knowledge specification. Information sources that are deemed to be useful are identified in preparation of knowledge acquisition. In the context of building a recommender system for power supplier, three main sources have been identified and are documented in *Table 1*.

S/N	*Source of Information*	*Insights from Information source*	*Knowledge acquisition technique*
1	Various Electrical supplier Factsheets	It provides basic information on different pricing plans: - Discounted or Fixed Rate - Cost per KWH - One time registration fee - Late payment charges - Early termination - Security deposit - Other fees and charges - Green power - Bundled offer - Incentives - Smart meter - Direct billing	Manual compilation from the various factsheets
2	Generic population	To validate and support the considerations with the individual profiles	Analyzing the results of the survey from the generic population

Table 1: Knowledge source and acquisition technique

3.2 KNOWLEDGE SPECIFICATION

3.2.1 BACKGROUND GATHERING

The team has done an extensive survey of the various electricity vendor recommendation systems currently available online. In-depth research has been done on each and every one of these systems to understand their rules, workflows and more importantly how these systems can be further enhanced. Many of these recommendation systems are fairly basic and fail to accurately represent the complexity present in the wide range of electricity plans available from the numerous vendors in the market. For example, many of these systems fail to accurately classify the pros and cons of a fixed vs discount off tariffs plan. There are also various small nuances that we feel can greatly impact an applicant's decision on the plan, such as whether a security deposit is required or whether the company providing the service is an established brand. All these factors were lacking in many of the current recommendation systems.

3.2.2 SURVEY

In addition, in our effort to design a more robust recommendation system, the team has also done a detailed and extensive survey to gain insights on actual consumer behaviors and what consumers are actually looking out for in a plan. These insights were then evaluated and incorporated into our rules and workflow for our recommendation system.

3.2.3 SME KNOWLEDGE

Due to the unpredictable nature of the discount off tariffs plan, the team has also decided to tap on the experience of one member of the team to better understand the key drivers behind electricity prices. He has been working in a top Oil and Gas MNC for the last 5 years and is currently a Pricing Tactics Advisor for the company. The key drivers behind electricity prices has since been built into the logic of our recommendation system as well.

3.2.4 MODEL LOGIC

Our recommendation system consists of 8 precise questions before recommending a specific plan to the applicant. Our team has incorporated additional questions such as monthly household income, whether their residence is owned or rented, whether applicant is risk adverse etc. All these questions will enable the recommendation system to provide a more robust and tailored recommendation of the electricity plans available. As mentioned earlier, the logic behind our recommendation system utilizes a mix of the statistical probability analysis from our survey results, in-depth research of the current available systems and also the industry knowledge from our team member. The logic can be split into 3 main phases.

The first phase of the logic will sieve out plans/vendors that are not relevant or applicable to the applicant based on their response in the questionnaire. For example, if the applicant has indicated that

they would not like to pay any security deposit, the recommendation system will filter out plans that does not require any security deposit. If the applicant has indicated interest in plans that have sign on incentives, the system will filter out plans that does not have any sign on incentives.

The second phase involves the recommendation system calculating and assigning a probability for each of the remaining plans based on the response of the applicants in the questionnaire. The probability or C.F for each rule is determined based on the statistical analysis of our survey results. For example, based on our survey results, for applicants where their apartment is owned rather than rented, 52% of the applicants would prefer electricity plans that have at least 1 year of contractual period. Hence C.F. of 0.52 is built into the rules of our recommendation system.

For the third phase of logic, the system estimates the average annual electricity cost based on the household size of the applicant and also the prices of electricity in the future. The average monthly household electricity consumption by household size is provided by the Energy Market Authority of Singapore and the Futures of electricity prices estimates are provided by the Singapore Exchange Limited (SGX). With the estimation of the average annual electricity cost, the system will then rank the remaining plans based on the most cost-effective plan. The system then applies a factor based on the ranking of these plans on top of the probability that was calculated in the second phase of the logic. The system finally recommends the applicant the plan that has the highest probability factor.

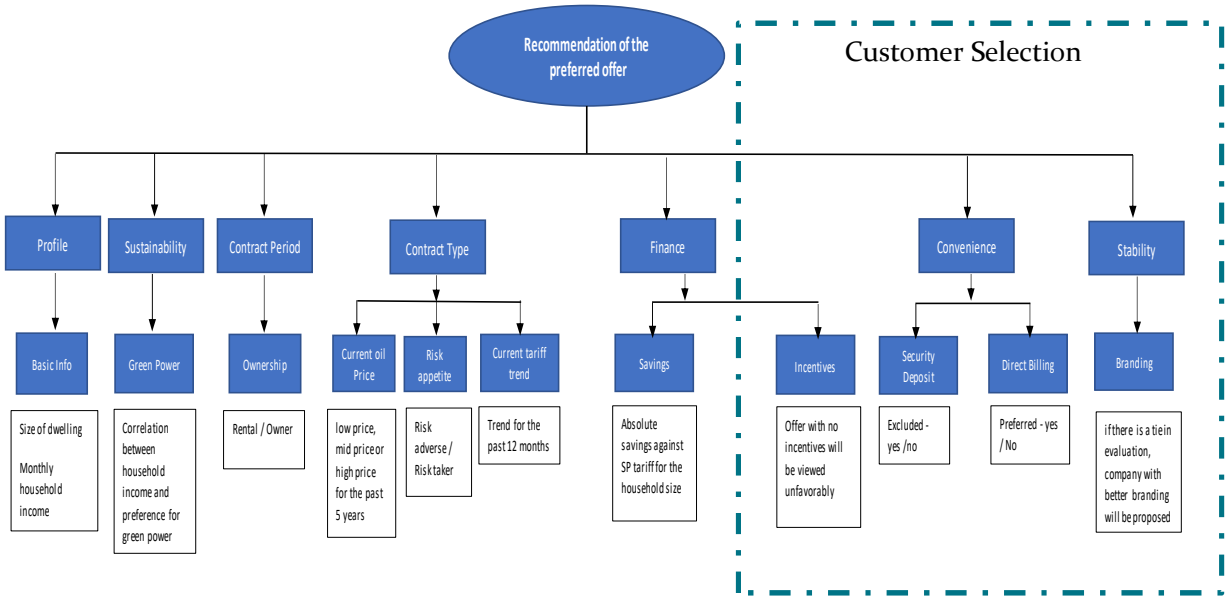

Figure 5: Dependency diagram of Electrical Supplier Recommendation System

3.3 KNOWLEDGE REFINEMENT

Figure 6 explains knowledge refinement as an iterative process comprising of (i) model validation & verification as well as (ii) model reinforcement. The former is conducted by obtaining results through running simulations of test cases in the existing system. The collected results are then validated with a subject matter expert who can advise for potential areas of improvements. On the other hand, the latter, considers various rooms for improvements, bolsters the existing model with the newly acquired tacit knowledge.

An example of an iteration is the inclusion of certainty factors into the knowledge model so as to manage the uncertainties in humans' preferences.

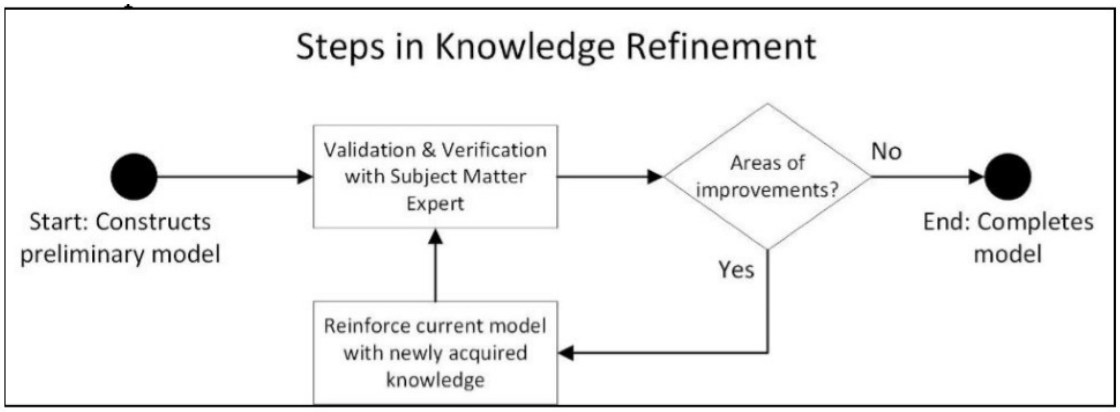

Figure 6: Steps taken in knowledge refinement

4 SOLUTION

The development of a knowledge model in section 3 enables the structuring of a rule-base which specifies the knowledge and reasoning requirements of selecting electrical power supplier. It also forms the kernel of the problem-solving strategy, which has been modelled as an assessment task, to recommend the most suitable electrical supplier to the user. The strategy considers the inputs of the users and draws the necessary inferences which then structures the subsequent questions and influences the output result by introducing the certainty factors.

4.1 SYSTEM ARCHITECTURE

The strategy is implemented using CLIPS and is brought to life using Python programming language (Django) in the form of a web-based graphical user interface which users can easily interact with. *Figure 5*, the system architecture diagram, illustrates how the application in the front-end has been interfaced with the back-end rule-based system and relational database. The latter was created to store information on the different pricing plans which were compiled from the factsheets of individual pricing plans.

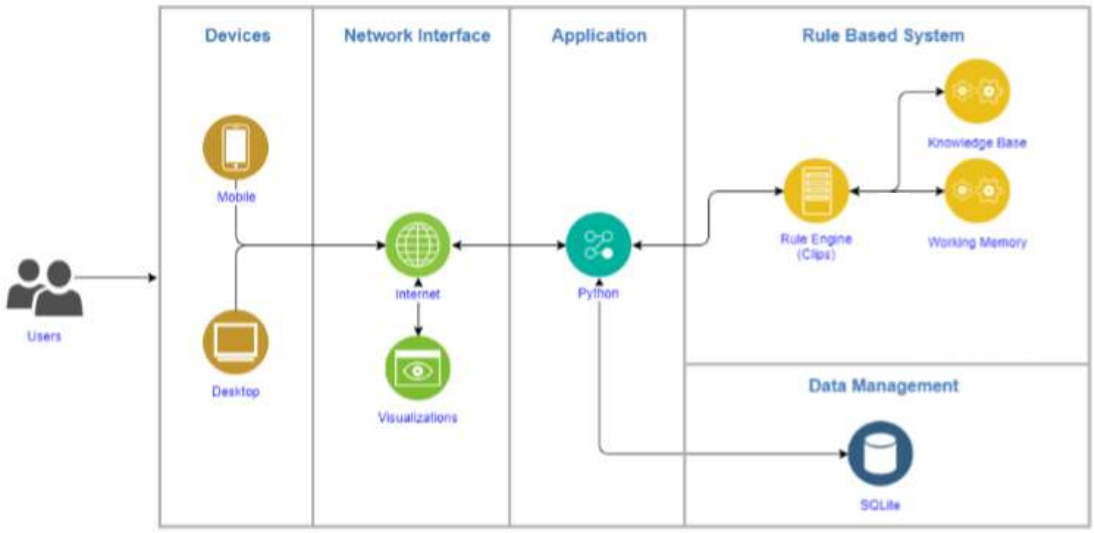

Figure 5: Power Supplier Recommender – System Architecture

4.2 PROJECT SCOPE

While data mining can be performed continuously, in the context of this project, its scope is limited by the date and time of pricing plan data. The system provides a snapshot of the fixed pricing plans and does not cover the flexi plans. However, the team believes that the list of fixed plans provided by 13 suppliers is sufficient due to the complexities of the flexi plans.

4.3 ASSUMPTIONS

KNOWLEDGE ACQUISITION

(i) Data available from the various power suppliers' websites are accurate at the point of extraction (1 March 2019)
(ii) Survey results is representative of the generic population. Due to time constraints, a total of 76 responses were collected.
(iii) Sign-up incentives are intangibles with small monetary value, if any. They have not been included in the calculation of the different price plans.

4.4 SYSTEM'S FEATURES

Despite the reduced scope and assumptions, the team has gone through an in-depth thought process to implement significant features in the recommender system which can substantially add value to potential users.

The recommender system is built on a web-based application with the consumers in mind. Anyone can access it easily via as a personal computer, mobile phones or tablets via the internet.

In addition, the interface is designed to provide users with the best browsing experience. For instance, the display window is dynamic and adjusts to the type of devices which the users are using. Radio buttons were also employed to improve the ease of users' inputs. Input checks are also in place to validate the information keyed in by the user.

4.5 LIMITATIONS

The entire decision process in choosing the right power supplier is complex as there is an several number of factors to be considered. Despite the conduct of the survey, it is inevitable that the system will fail to address the needs of the minorities. This group of people might assert on intangible factors such as incentives (e.g cashback, on credit cards, bundled plans), reputation of the service provider or other unforeseen aspects. While these factors were not part of the decision matrix, it is certainly possible to consider them during further enhancement of the system to provide a more comprehensive result.

5 CONCLUSION & REFERENCES

Our team had a wonderful time working on this project, and definitely picked up variety skills which we could really use in work life.

Finding a good project was our first challenge. A sound business case with financial value that is not already in the market is not easy, especially when the team is made up of personnel with different knowledge domain and areas of interest. After much brainstorming, we decided on a project which impacts all of us and focus on it.

Knowledge representation was critical to the success of the project. The team has learnt that decision making rules are often complex and have different weightage for based on individual preferences. By leveraging off the diverse backgrounds (oil and gas expert, financial expert of predictive modelling) and individual preferences to determine the rules, and calculating the weightage derived from the survey results, we were able to remove the ambiguity of importance of each rule in final recommendation.

The final step of building the system itself presented an exhilarating learning journey. The team undergo the learning wheel to understand the use of CLIPS system, as well as tap on our existing expertise in SQL, Python and UX web design using Django. Working on the project together allowed everyone to learn technical skills from one another, which is an added benefit over doing individual work.

Overall, it was truly a multi-dimensional problem which would not have succeeded without the contribution of the entire team. We have come to appreciate the usefulness of Rule-Based reasoning to solve everyday problems in a systematic manner.

5.1 IMPROVEMENTS AND FUTURE ENHANCEMENTS

If we had more time to work on this project, we would have:

1) Webscrap for dynamic input from various power suppliers and oil price website

We had manually input the various price plans and the rolling average of oil prices where the data may have been outdated. The reality is that the price plans are changing on frequent basis where different competitors seek to improve their market share. Oil prices are also highly volatile and changes on a daily basis. By using webscraping techniques, we could improve frequency to create a more dynamic recommender.

2) A more dynamic recommender

We have designed our recommender for a consumer looking to switch their power supplier for the first time. Going forward, the recommender could be used to be more robust to automatically perform periodic checks on the consumers' plan to validate that there are still on the "best" plan according to their preferences. In the event that a better plan comes onboard which hits above a certain user defined threshold (e.g. more than $300 savings per year), an automatically generated email alert will be sent to consumer for his consideration.

3) Building our knowledge base

We recognize that most survey respondents are people from within our social circle where the majority are Singaporeans living in HDB. Our group could have further improved our survey results by polling a larger variety of respondents in terms of ethnicity, age group, and especially people who are on short term stay in Singapore.

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OEM Retailer Logos from

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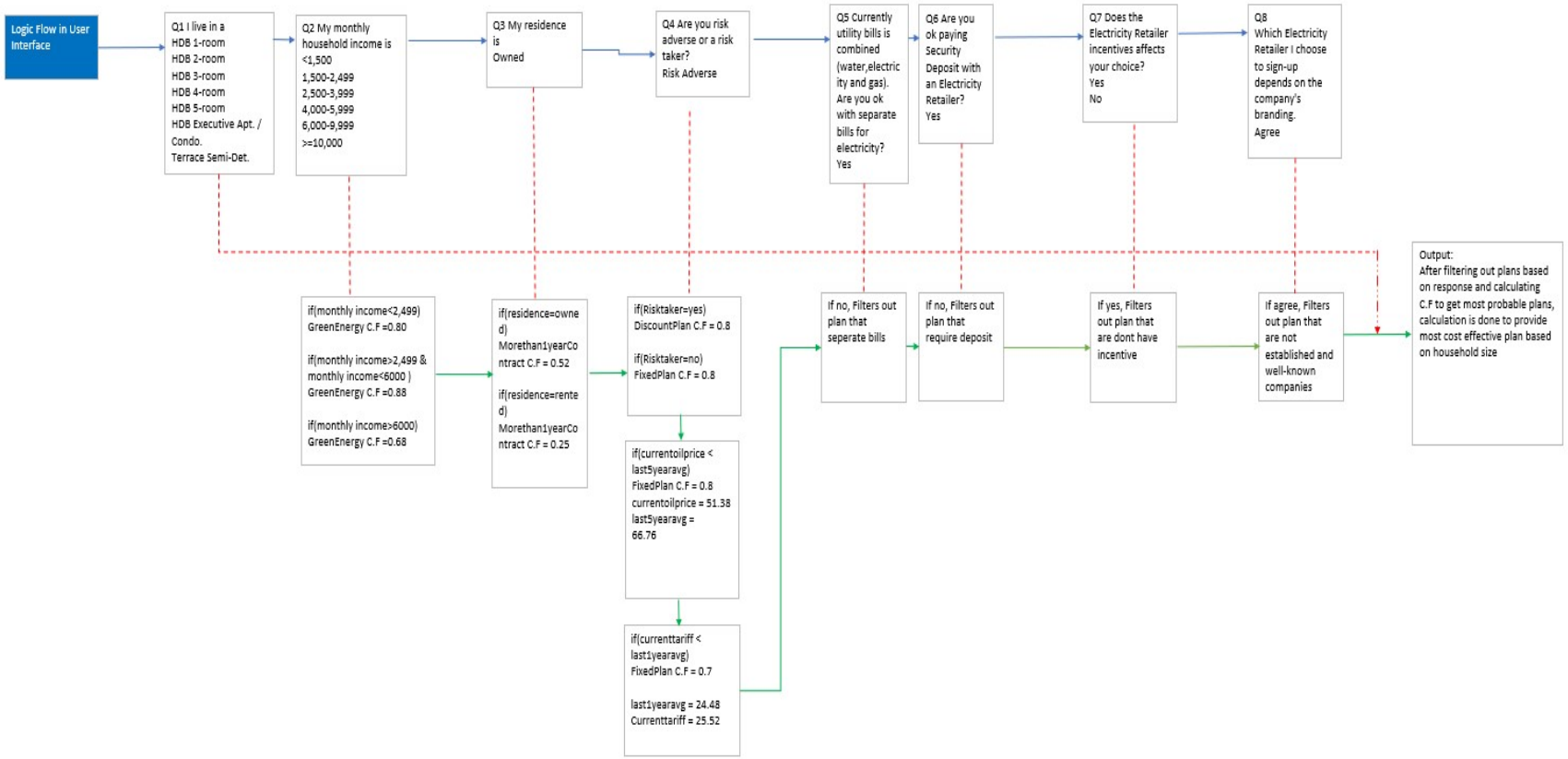
Power Supplier Recommender Application is amended from

https://github.com/jarvis57/Food-Plus

7 APPENDICES

Power Supplier Recommendation: Business Process Model

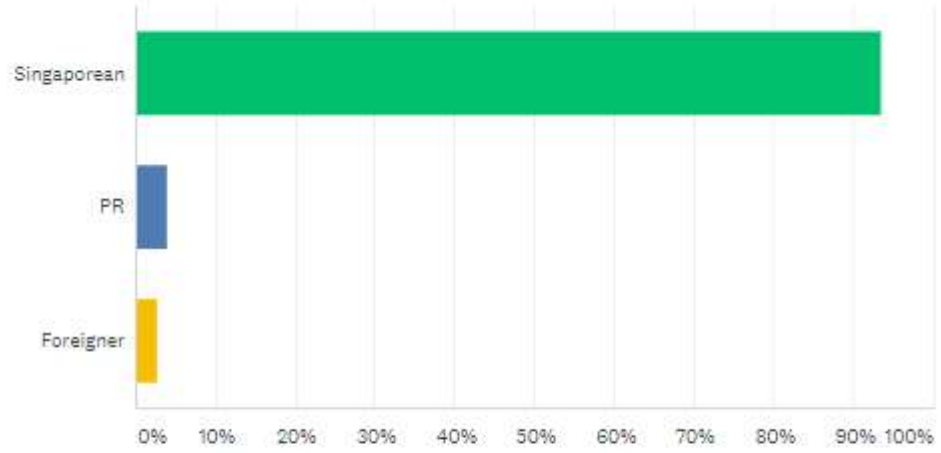


Survey Results

Q1

I am a

Answered: 76 Skipped: 2

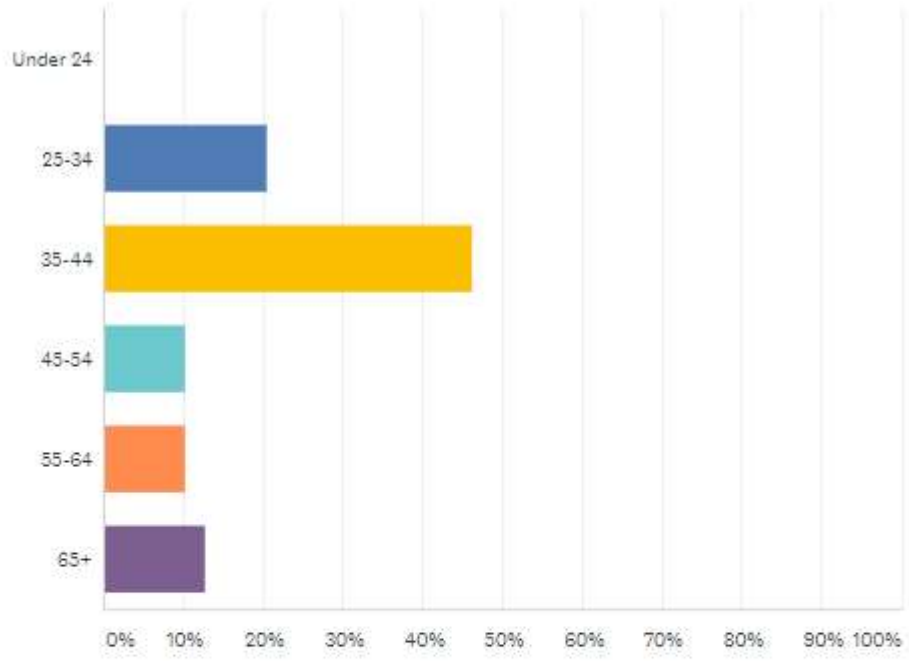


ANSWER CHOICES	RESPONSES	
Singaporean	93.42%	71
PR	3.95%	3
Foreigner	2.63%	2
TOTAL		76

Q2

My age group is

Answered: 78 Skipped: 0

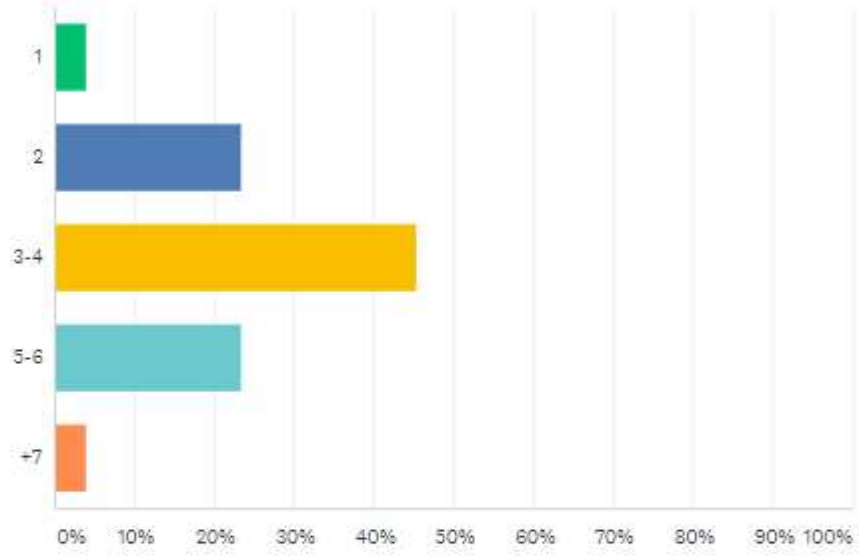


ANSWER CHOICES	RESPONSES	
Under 24	0.00%	0
25-34	20.51%	16
35-44	46.15%	36
45-54	10.26%	8
55-64	10.26%	8
65+	12.82%	10
TOTAL		78

Q3

The number of persons(including children) in my household is

Answered: 77 Skipped: 1

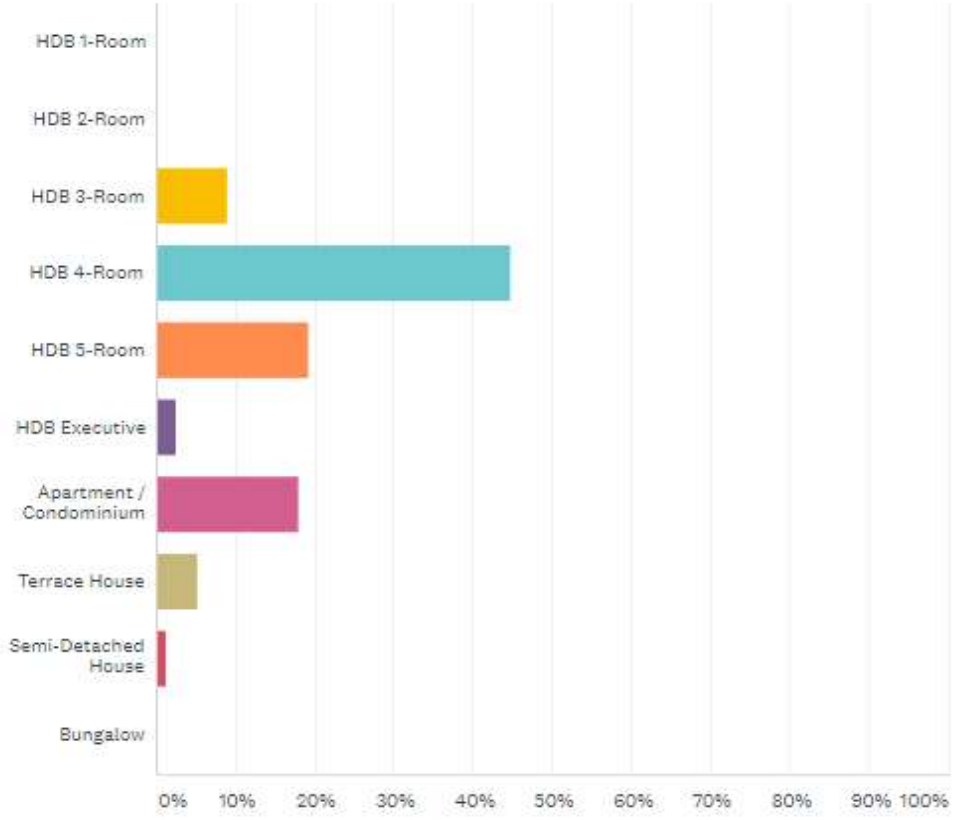


ANSWER CHOICES	RESPONSES	
1	3.90%	3
2	23.38%	18
3-4	45.45%	35
5-6	23.38%	18
+7	3.90%	3
TOTAL		77

Q4

I live in a

Answered: 78 Skipped: 0

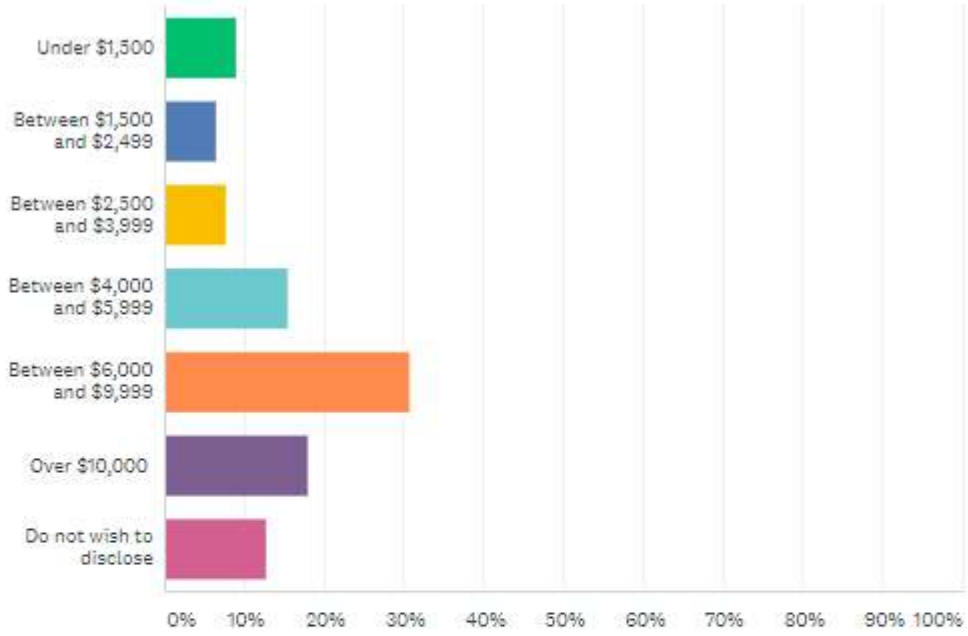


ANSWER CHOICES	RESPONSES	
HDB 1-Room	0.00%	0
HDB 2-Room	0.00%	0
HDB 3-Room	8.97%	7
HDB 4-Room	44.87%	35
HDB 5-Room	19.23%	15
HDB Executive	2.56%	2
Apartment / Condominium	17.95%	14
Terrace House	5.13%	4
Semi-Detached House	1.28%	1
Bungalow	0.00%	0
TOTAL		78

Q5

Monthly Household income

Answered: 78 Skipped: 0

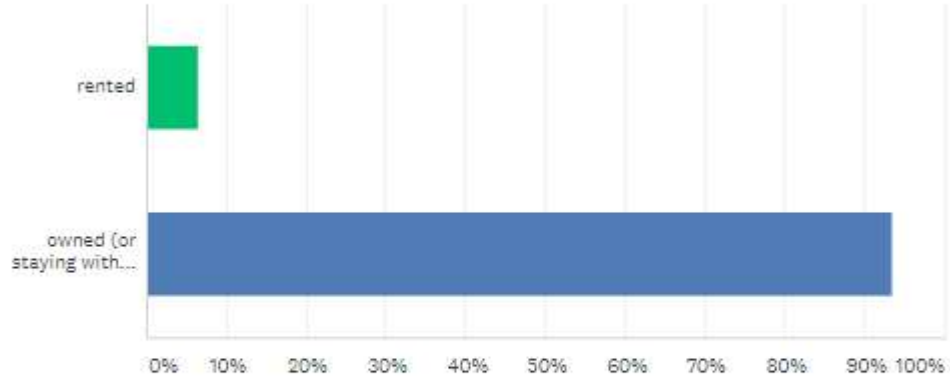


ANSWER CHOICES	RESPONSES	
Under $1,500	8.97%	7
Between $1,500 and $2,499	6.41%	5
Between $2,500 and $3,999	7.69%	6
Between $4,000 and $5,999	15.38%	12
Between $6,000 and $9,999	30.77%	24
Over $10,000	17.95%	14
Do not wish to disclose	12.82%	10
TOTAL		78

Q6

My residence is

Answered: 78 Skipped: 0

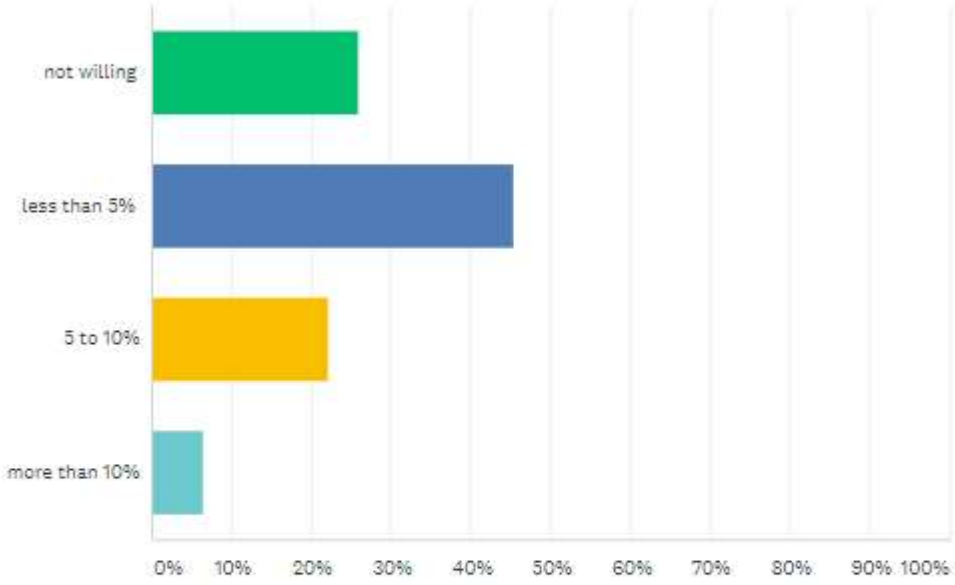


ANSWER CHOICES	RESPONSES	
rented	6.41%	5
owned (or staying with parents)	93.59%	73
TOTAL		78

Q7

How much more are you willing to pay for green energy?

Answered: 77 Skipped: 1

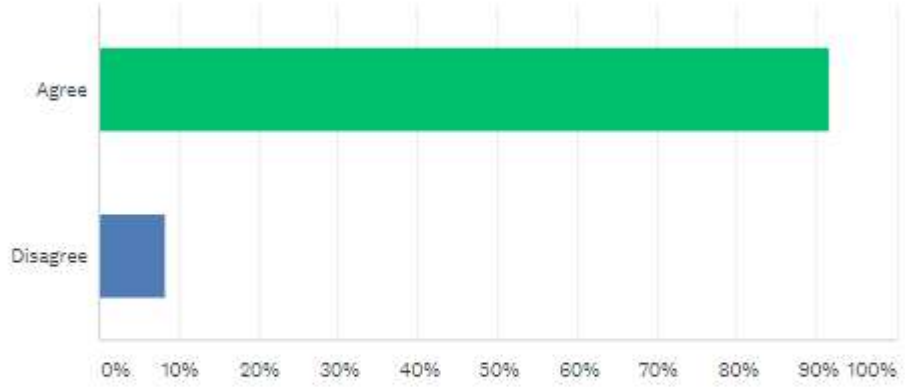


ANSWER CHOICES	RESPONSES	
not willing	25.97%	20
less than 5%	45.45%	35
5 to 10%	22.08%	17
more than 10%	6.49%	5
TOTAL		77

Q8

Which Electricity Retailer I choose to sign-up depends on the company's branding/stability

Answered: 72 Skipped: 6

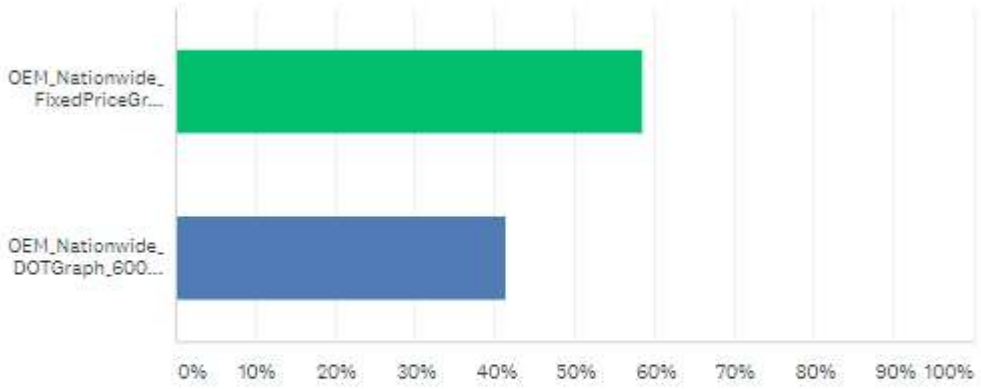


ANSWER CHOICES	RESPONSES	
Agree	91.67%	66
Disagree	8.33%	6
TOTAL		72

Q9

What type of plan do you prefer (Fixed price or Discount off regulated tariff)?

Answered: 70 Skipped: 8

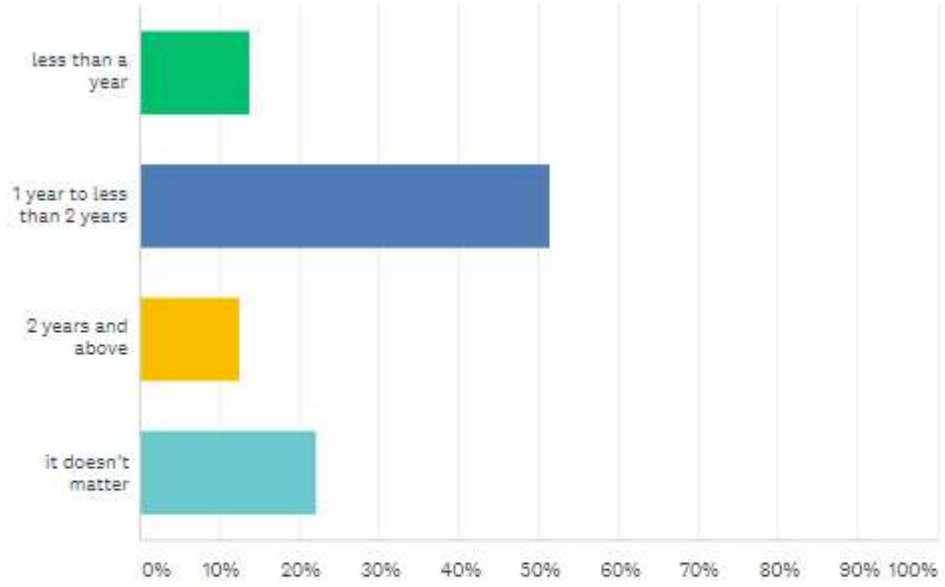


ANSWER CHOICES	RESPONSES	
[illegible]	58.57%	41
[illegible]	41.43%	29
TOTAL		70

Q10

What contract period would you prefer?

Answered: 72 Skipped: 6

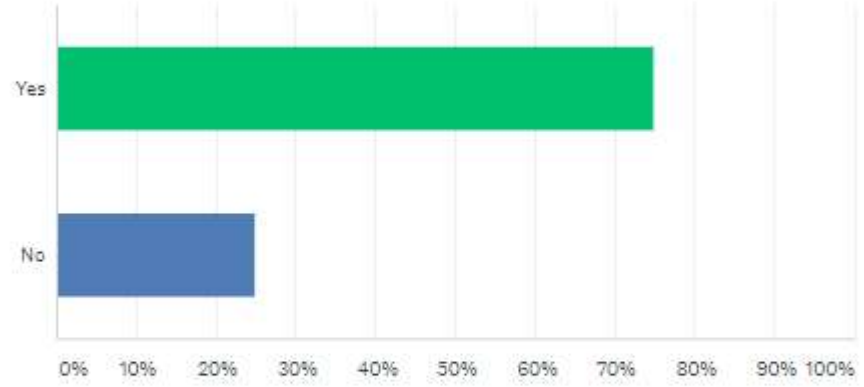


ANSWER CHOICES	RESPONSES	
less than a year	13.89%	10
1 year to less than 2 years	51.39%	37
2 years and above	12.50%	9
it doesn't matter	22.22%	16
TOTAL		72

Q11

Currently utility bills is combined (water,electricity and gas). Are you ok with separate bills for electricity?

Answered: 72 Skipped: 6

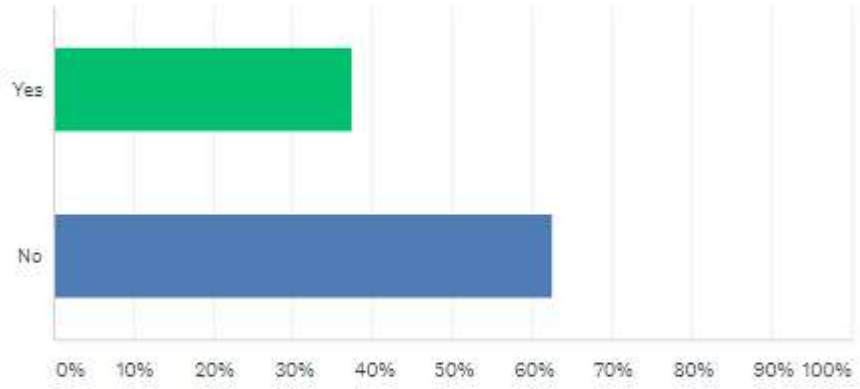


ANSWER CHOICES	RESPONSES	
Yes	75.00%	54
No	25.00%	18
TOTAL		72

Q12

Are you ok paying Security Deposit with an Electricity Retailer?

Answered: 72 Skipped: 6

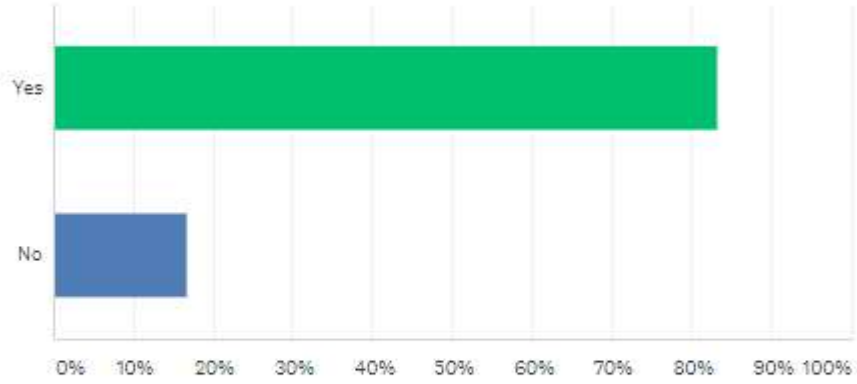


ANSWER CHOICES	RESPONSES	
Yes	37.50%	27
No	62.50%	45
TOTAL		72

Q13

Are you concerned about early termination charges?

Answered: 72 Skipped: 6

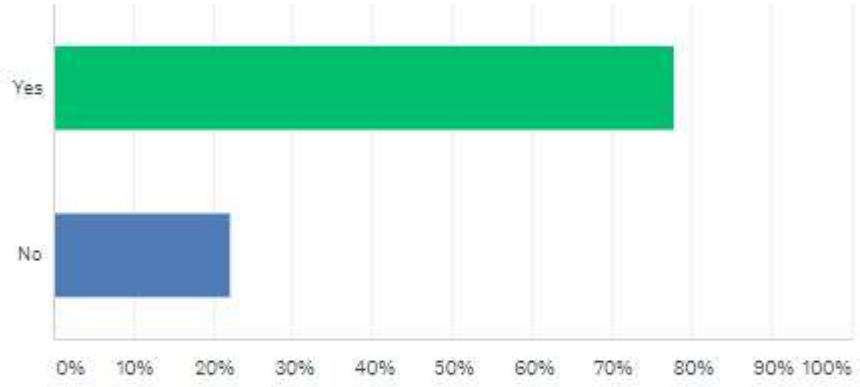


ANSWER CHOICES	RESPONSES	
Yes	83.33%	60
No	16.67%	12
TOTAL		72

Q14

Does the Electricity Retailer incentives affects your choice?

Answered: 72 Skipped: 6



ANSWER CHOICES	RESPONSES	
Yes	77.78%	56
No	22.22%	16
TOTAL		72