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Solar Thermal Installation Capacity: Malaysia Small Medium Enterprises with and Without Fiscal Incentives

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ABSTRACT

This paper presents a comparison of solar thermal installation Capacity (STIC) with and without fiscal incentives for Malaysia Small Medium Enterprises (SME) sub-sector. The solar thermal installation capacity was measured through a policy evaluation system developed. The STIC was produced by System Dynamics Simulation (SDS) technique to measures the changes in installation capacity caused by SME acceptance, project risk and techno-economic analysis. The data were statistically analyzed to predict the optimal STIC between the fiscal incentives SDS models and non-fiscal incentives SDS models. The results revealed that the fiscal monetary and know-how on the solar thermal heating technology had the significant influence on the non-fiscal incentive SDS model, however, the fiscal incentives SDS models gave the best representation of level of installation capacity. The effect of the low percentage obtained on non -fiscal incentives SDS model has shown that solar thermal policy maker need to take into account that type, program and mechanism of incentives will give an impact the policy to be developed for SME heating process industries

Key words: Solar Thermal Fiscal Incentives, Solar Thermal Heating, Solar Thermal Policy, System Dynamics Simulation.

1. INTRODUCTION

Solar energy is one of the most reliable energy source available in the world. It can be harvested in two ways, firstly through solar photovoltaic panel and secondly, solar thermal collector. It depends on the application objective of energy usage since solar energy can be transformed into electrical energy and heat energy. Emission of solar energy is depending on the wavelength, which reliant on the temperature and radiation intensity.[1],[2]. Malaysia is one of the luckiest countries to have abundant sun radiation. Due to that reason, Malaysia has great opportunity to explore solar energy. Malaysia already has tremendous amount of penetration on solar photovoltaic usage. On the other hand, very less on solar thermal energy using solar thermal collector. There are lots of benefits that can be gained from solar thermal energy.[3],[4] Heating is the most needed process in Small Medium Enterprises (SME) industries such as dairy, drying, and other processes. For the long run, solar thermal heating is the cheapest technology compared to other fossil fuel heating energies source since solar energy is free. Recently, Malaysia is doing so much efforts migrating to solar thermal since Malaysia has fixed targets for seventh sustainable development goal, affordable and clean energy for 2030 agenda [5],[6]

In Malaysia, solar heating energy is new and has great potential [7],[8]&[9]. In average, Malaysia receives 6 hours of daily solar radiation. It also depending on the season and location in Malaysia. This year, Alor Setar and Kota Bharu have received almost 7 to 8 hours of solar radiation in January. At the same time, Kuching has received only 3.7 hours as been reported by Malaysian Meteorological department. In July 2019, Kuala Terengganu meteorology station has recorded the highest average amount of daily radiation, 20.04 MJm^{-2}. Kuala Terengganu has recorded positive deviation up to +2.46 MJm^{-2} and highest negative deviation was recorded by Ranau, 2.28 MJm^{-2}.[10]. Some research has been reported on Malaysia energy policies; the results that the energy policies are only focusing on electricity generation and none on heating energy and SME heating process industries. Recently there were 2 papers discussed renewable energy. The paper mentioned are discussed a heat transfer on straight tube [11] and renewable energy storage hydrogen storage[12]. None of it are discussed on renewable energy policies nor the incentives... Indeed, research on heating energy policies are still in its infancy.

The author of [13] has highlighted in his paper that India government has supportive policies for implementation of solar energy. The India government in Odisha state has expected to generate 30 GW of solar thermal power. Spanish Municipalities has applied few programs and incentives on solar thermal installation before implementing tax credits as one of ways to promote solar thermal energy. [14]. The author of [15] mentioned that by adopting the tax bonus able to increase the solar thermal installation in the Andalusia municipalities. Ehsanul Kabir[16], has stated that beneficial collaboration together with regulation policy framework able to increase the solar power technology development especially on research. Matti Pihlajamaa in is paper has mentioned that there are few requirement need to look into for having innovation policy to emerge high-tech industries[17]. At European level, the European Solar Thermal Industry Federation (ESTIF), has presented three main initiatives to promote solar thermal industry such as having financial and non-financial incentives along with the legislative framework, do promotion at local level and elaborating the " International Energy Agency Solar Heating and Cooling Roadmap".[18]. Generally, most of researcher have discovered that solar thermal technology need policy and incentives as one of boosting factors for increasing solar thermal installation capacity. In Malaysia there are several policies available for renewable energy but none of the policies is applicable to SME heating process industries and specifically design for solar thermal technology system. These can be evidenced from the several papers presented as mentioned below. The author [19], has discussed on issues, challenges and promotion on efficient utilization renewable energy for electricity generation in Malaysia. Heap-Yi Chong [20] had state that Malaysia has great potential for electricity generation from ocean renewable energy of the Straits of Melaka. Most of policy discussed by [20] are on electricity generation. Recently, Tick Hui Oh, [21], has state that Malaysia has major changes in energy and electricity generation. In his paper, he has listed all policies available together with the objectives. Unfortunately, none of the policy has seen the potential of solar thermal heating in SME heating process industries. Chiang-Ching Tan[22], has concluded that the reduction of energy consumption may affect economic growth specifically in Malaysia's industrial sector.

Therefore, a substantial study on the policy evaluation of heating energy is a necessity for action for solar thermal specifically for SME heating process industries to support the heating energy demand.

Solar thermal heating technology is different from solar photovoltaic system. The solar thermal heating technology will transfer solar radiation into heat. The system is capable to serve as heat source. To abstract heat from solar radiation, there are several solar collectors are available in the market such as solar chimney (heat the air with the structure), evacuated tube solar thermal collector (ETC), flat plate solar thermal collector, thermodynamic panels, solar thermal air collector and solar thermal bowl collector. Among all collectors, ETC is the most popular solar system used for heating water system due to its 70% rate of efficiency. It has excellent insulation and unaffected by air temperatures.

The ETC is made from insulated glass tubes. It uses copper pipes to send the water heated in the collector to the water tank. Solar thermal heating system contains of several key components such as solar collector, thermal storage (hot water cylinder), heating system controller, pump (depending on the system), mounting kit, and pipework. There are 4 types of solar water heating system. 1. Active system, 2. Passive system, 3. Direct system, and 4. Indirect system.

Global Solar Thermal Energy Council has taken the initiative to update the solar thermal energy progress globally. It is a platform for solar thermal professionals to get the latest news on solar thermal technologies. In general, not all countries in this world do have solar thermal policy dedicated to heating process industries. As stated in the web portal, only twenty (20) incentives programmes or policy applicable for industries application. It has been tabulated as in Table 1

Table 1: Incentives and policy available for industries globally

No	Country	Programme name	Type of incentives
1	Armenia	Caucasus Energy Efficiency Program II (CEEP II)	Loans and grants. Applicable for private companies for renewable energy investments
2	Austria (2017)	Solar thermal – large-scale systems- non- residential application	Investment subsidy
3	Balkans	Western Balkans Sustainable Energy Financing Facility II (WeBSEFF II)	Combination loan and grants
4	Denmark	RE to Production Processes	Grants
5	France	Call for proposals NTE (New Emerging technologies) / "Appel à projets Nouvelles technologies émergentes (NTE)"	subsidy
6	France	"Appel à projets national Grandes Installations Solaires Thermiques(National call for projects Large Solar Thermal Installations)"	Investment grant
7	Georgia	Caucasus Energy Efficiency Program II (CEEP II)	Combination of loans and grants
8	Germany	Market Rebate Programme for Renewable Energy	Subsidies- process heat receives incentives according to the MAP basic tariffs
9	Great Britain	Carbon Trust Interest-Free Loans	Loan
10	India	Industrial and Institutional solar thermal collector systems for water heating needs targeting 0.4 million m² until January 2016	Rebate- industries for process heat and cooking
11		Capital subsidy scheme for installation of solar thermal systems	Subsidy combined with low- interest loan
12	Italy	Mechanism of Renewable Heating Systems and Energy Efficient Measures (small size) – "Conto termico 2.0"	Rebate base on the expected performance level
13	Netherlands	Energy Investment Allowance (EIA)	Tax credit for entrepreneurs- industrial process

14		SDE+	Feed-in Tariff- for 700 full load hours per year for over maximum 15 years
15	Norway	Grant Scheme for "Small Heating Plants"	Subsidies provided on a case-by-case basis
16	Romania	Sustainable Energy Finance Facilities EEFF, RoSEFF & MFFEE	Low-interest loans and grants for energy efficiency and renewable energy projects-EEFF-Production companies RoSEFF - Small and medium-sized enterprises (up to 250 employees and a turnover of EUR 50 million)
17		Energy Efficiency in the Industry for SMEs (RO 05)	Grants -
18	Slovenia	Public tender for co-financing district heating using renewable energy sources for the period 2017 to 2020	Investment subsidy
19	UK	Non-domestic Renewable Heat Incentive (RHI)	Payment to the end-user every ¼ year related to the quantity of renewable energy produced by the system
20	United States	California Solar Initiative (CSI) - Thermal Program	Up-front incentives based on estimated first-year terms or kWh replaced

2. SYSTEM DYNAMIC SIMULATION TECHNIQUE

SDS techniques is a system that able to analyze the sensitivity of the system and portrait the behavior of the system.[23]. This technique able to analyze the risk problem of the system by combining SDS with Monte Carlo Simulation[24]. Michael Mutingi in his 3 papers [25],[26]&[27] has stated that SDS is normally known as a tool for modelling a policy design. The System Dynamics was introduced by J Forestor by 1960's.
The author [28],[29]&[30] has used system dynamics for policy modeling design. Zhi Qiang,[31] to used system dynamics simulation for analysis studies on China's solar photovoltaic policy. Mehdi Fateh Rad in his work, has used SDS for investigate the relationship between university and industry by developing system dynamics model.[32].
In order to identify the STIC influence factor to predict the optimum installation and to evaluate the effectiveness of the incentives introduce to the system. Formulation of the modeling were determined according to the [33]procedure as described.
A TREND function is being used in the STIC mathematical modeling. As mentioned by J.D.Sterman, the TREND function will allow *"the trend in input variable to adjust gradually to the value indicated by the most recent data"*. In other words, the TREND function models allow forming the expectation on the rate of changes or growth in the variable. It was done by founding on the "*history of the variable itself*"[33]. Since STIC modelling is a growth expectation model therefore, TREND function is the best function suited. The TREND functions in SDS able to generate the expected rate of changes in input variable.
General STIC perceived trend is based on System Dynamics first-order exponential general equation ((1) to (10)) perceived trend by J.D.Sterman 1987[33] is as shown below

General STIC equations

$$STIC_{t_0-t_{20}} = \int_0^{20} change\ in\ STIC, STIC \quad (1)$$

$$\textbf{Change in STIC} = \textbf{Investment Decision} \quad (2)$$

$$\textbf{Reference condition}_1 = \textbf{SME Acceptance} \quad (3)$$

$$\textbf{Reference Condition}_2 = \textbf{Risk Free} \quad (4)$$

$$\textbf{Referenc Condition}_3 = \textbf{Technoeconomic influence} \quad (5)$$

$$\textbf{Time Horizon for refence condition} = \textbf{2015} \quad (6)$$

$$\textbf{Preceived Present Condition} = \textbf{NPV} \quad (7)$$

$$\textbf{Time to Perceive Trend} = \textbf{Time to Perceive Present Condition} = \mathbf{T_n} \textbf{ where } \mathbf{n} = \mathbf{1, 2, 3 \ldots \ldots 20} \quad (8)$$

$$STIC_{kWh} = \begin{cases} 100kWh\ for\ every\ 10\%\ increament\ of\ investment\ decision\ between\ 0\%\ to\ 55\% \\ 1000kWh\ for\ 10\%\ increament\ of\ investment\ decision\ between\ 56\%\ to\ 100\% \end{cases} \quad (9)$$

$$\textbf{Indicated STIC} = \textbf{combination of of } \sum(\textbf{Reference condition}_{1,2,3} *) \quad (10)$$

To model the STIC, the Stock and Flow Diagram were developed first before future work to be carried out..
shows the general diagram of STIC model. Next step of modeling is developed stock and flow diagram as shown in **Error! Reference source not found.**.Figure 2 . This STIC diagram is a combination of 3 sub-models, techno-economic model [30], SME acceptance model [28] and risk model[34]. In order to combine all models some adjustments were done due to redundancy and boundaries set. The boundaries of the STIC are no policy and incentives and limited of solar thermal sources (in terms of technical knowledge, application, market price and demand on user-side (SME), no government support). The STIC stock and flow diagram is complicated and

big. The current of STIC model has been added few possible incentives based on summary of solar thermal global incentives as tabulated in Table 1. scale

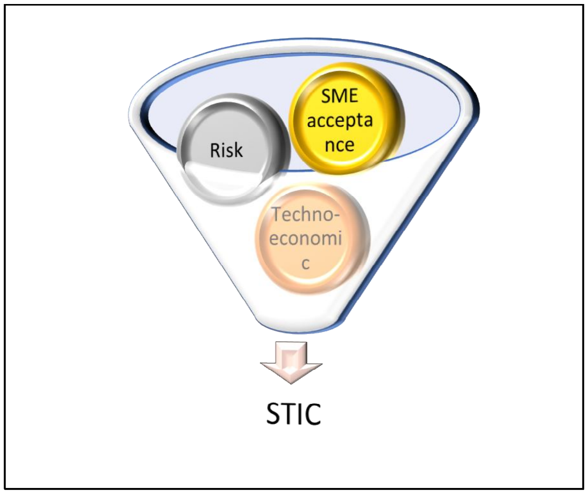

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Figure 1: STIC general model without incentives

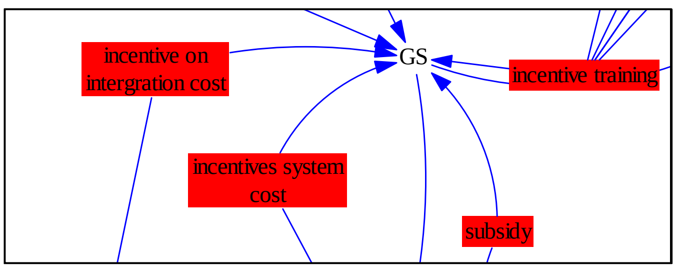

Figure 2 Incentive proposed to the existing STIC model.

Detail of incentives (**Error! Reference source not found.**) proposed and added to the system are cost incentives of system integration, cost of the system such as solar collector, pump, heating storage and control system, incentives on training and subsidy on upfront cost. Due to complexity of the systems and learning paradigm, the model developed was tested and when through several validation processes as suggested by J.D.Sterman. to ensure the results generated by the STIC model achieving relative trust on structure and behaviour of the system [35], [36],[37],[38],[39],[40],[41] and [42]. Instead of testing the accuracy of the result, it also helps to understand the information generated and utilized by the STIC model. The validation processes used several methods as shown in **Error! Reference source not found.**. The test assessments are boundary adequacy, structure assessment, parameter assessment, integration error test, behaviour reproduction test, sensitivity analysis, and system improvement.

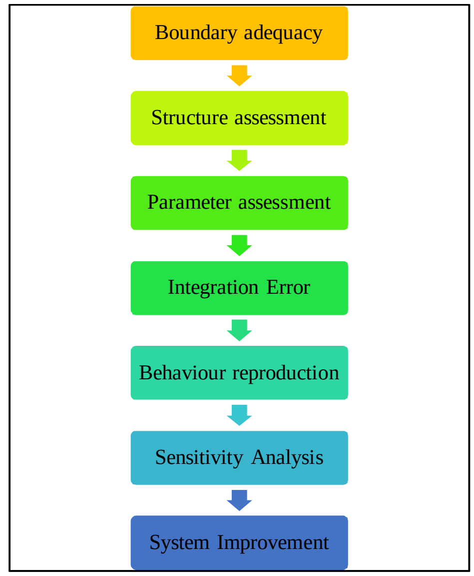

Figure 3: Validation tests for STIC System dynamic model

Each validation process has its purpose. Boundary test is used for testing the behavior of the model by monitoring the significant changes. The structure assessment test is used for capturing the behavior of the parameter in the system. both boundary and structure test are to find externalities and side effects. Parameter assessment is to determine the consistency value of the certain parameter with pertinent descriptive of the system. Behavior reproduction is to monitor the reproduce the behavior of the installation capacity in the system qualitatively and quantitatively. This validation process was done by comparing the model output such as modes of behavior, shape and relative amplitudes generated. Sensitivity analysis was done to foresee the policy implications on the system by varied the parameters within reasonable range. System improvement is done for assessing the impact of the modeling process for instance mental models, behavior and outcomes

3. RESULT

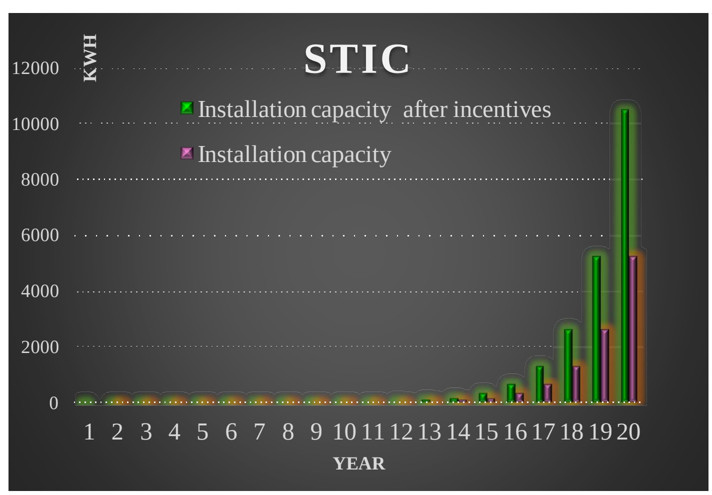

Figure 4: Comparison output of the STIC. (with and without incentives

Error! Reference source not found. shows the combination of STIC simulations result between STIC non incentives and STIC with incentives. The trend of the figure has shown very slow progress of STIC non incentives model compared to STIC with incentives the variation of the installation capacity represents the investment decision of SME industries toward the cost of the project implementation. **Error! Reference source not found.**. The STIC with incentives had increased tremendously for the last five years (sixteenth, seventeenth, eighteenth, nineteenth and twentieth year). on the other hand, it also shown a very small installation compare in the beginning of year. Yet, the STIC without incentive has shown almost 0 kwh or first two years after introducing the system and gradually increasing in KWh for last 5 years.

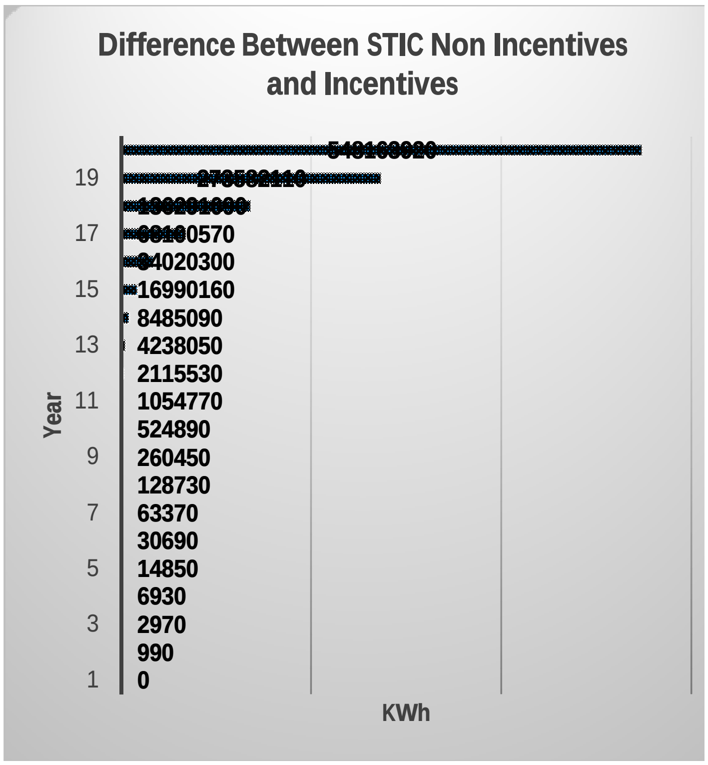

Figure 5: Difference between STIC non incentives and incentives

Figure 5 shows the variance between STIC with incentive and STIC non incentive is obvious almost 50% and more for each year except for the first year since it is new and need more promotion on the technology and the policy. The increment of n both STIC results (with and without) show sluggish increment for early years, this may due to lack confident on solar thermal technology in term of return of investment.

Figure 6, has shown the SME decision pattern in next 20 years. It has discovered that the investment decision is greatly higher for the STIC model with the incentives, even in the first year of introduction of Solar Thermal heating technology. The Figure 6 has proved the behavior of SME investment pattern where the STIC will increase when the support from government is available especially the monetary support.

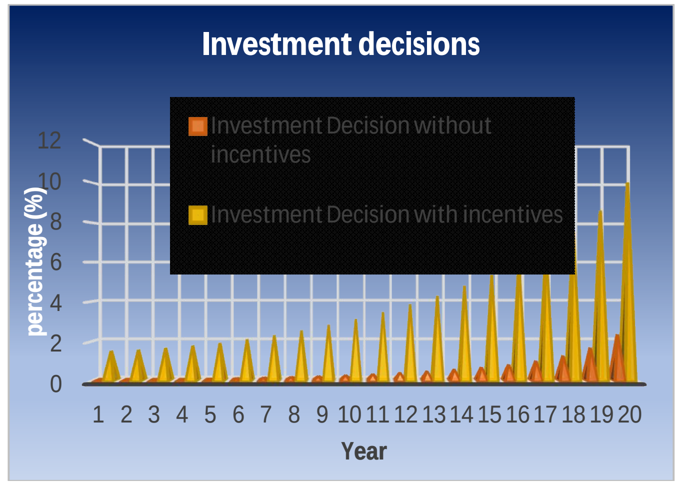

Figure 6: Investment decisions toward STIC models (with and without incentives)

4. CONCLUSION

In this work a new model of STIC has been developed to anticipate the impact of implication of incentive to the system. It was found that incentives had greatest influence on SME investor. The difference of capacity is high. It is effective to improve the installation capacity compare to current situation where there is no policy and incentives for solar thermal investor. This findings can be used by policymaker as reference since the SME investors are more confident when the supports and proper regulation from government are available such as financial, support on human expertise, monetary matter, and tariff since majority of the SMEs are not willing to invest using the company budget. Therefore, for further works, more incentives mechanism and type of solar thermal collector to be taken into account to describe the STIC in the policy evaluation tool.

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