Evaluation of Feed-in Tariff policy effects on sustainable development of renewable energies in Iran: A System Dynamics Approach

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Abstract: Sustainable development of renewable energies is one of the most fruitful solutions that governments use for facing the challenges like greenhouse gases emissions, global warming and energy security. Feed in tariffs (FiT) as an efficient policy that supports the renewable energies development, has been implemented around the world for years. This Policy will be successful if the financial mechanisms work properly. Iran started the implementation of FiT policy from 2015. In this Paper, a System Dynamics model is proposed to evaluate the effect of FiT policy on renewable energy development in Iran. Consideration of several sociological effects emanated from financial mechanisms differentiates this research and its model from the previous works. According to the results, the system behaves well till 2021; however, a financial crisis will occur afterwards, leading to inefficient growth of renewable energies. By analyzing the dynamics of the system, three policies are proposed and applied to the model. The best policy that results in sustainable development without any negative sociological effect and financial crises is to adjust taxes for development of renewable energies, according to the budget availability.

Key Words: Feed in Tariffs (FiT), Renewable energy, sustainable development, system dynamics.

1- Introduction

Despite the fact that Iran is an energy-rich country, both energy security and carbon emission mitigation require faster development of renewable energies. Therefore, due to the little share of renewable energies in the current energy portfolio, expanding the electricity production from renewable energy resources is notably crucial. The present shares of gas and oil in Iran's electricity generation portfolio is almost 90%. Iran's energy resources management for the next decades is a strategic and important issue as many researchers are putting a lot of effort to formulate a proper energy development strategy.

Increasing usage of fossil energy sources as an exhaustible natural resource has increased concerns about the future of world's energy supply. On the other hand, the use of fossil fuels causes irreparable harm to the environment; and its side effects such as global warming caused by greenhouse gas (GHG) emissions, acid rain, Oceans water heating water and atmospheric pollution, make all nations face big challenges. Iran is responsible not only to itself but also to the world because of reaching the 8^{th} rank among CO_2 emitter countries, with 616 million tons per year (Global carbon atlas, 2015). Also, Iran has gone ahead of its neighbors like some Middle East countries and other countries like Spain and Greece in CO_2 emission per capita metric in the recent years.

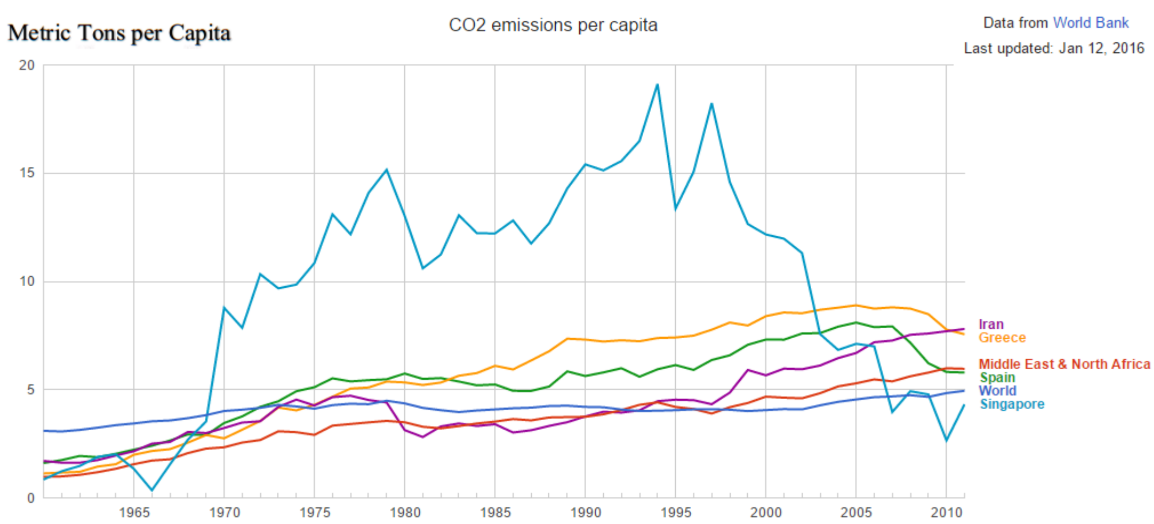

Figure 1. CO2 emission per capita (Iran in comparison with some other countries) - World Bank, 2016

Environment, society and economics are the fundamental aspects of the sustainability notion. Much of the world's energy is currently produced in ways that could not be sustained. Most of ambiguity cloud hanging over the concept of sustainable development of different countries is caused by the environmental pollution and the economic and social side effects of using limited fossil energies. The use of renewable and clean energy sources such as wind power, hydropower, solar, etc. has been the most proper way that humans have ever adopted in order to face these challenges. Utilization of these energies is growing rapidly so that according to the medium-term renewable energy market report in 2014 provided by the International Energy Agency, renewable energies experienced their fastest growth in that year. In the same year, 13% of the total energy demand in America was met by renewable energies (EIA 2014).

For example, wind energy as one of the most developed kinds of renewable energies (excluding hydropower) has attracted government's attention in recent years. In 2013, The International Energy Agency's Forecast claimed that by 2050, 18% of the world electricity need will be supplied only by the wind. In another study, this share is estimated to be between 25% and 30% (Global Wind Energy Outlook, 2014). Based on the Global Wind Organization report, about 25% of the installed capacity of wind power generation in the world will be in Asia by the end of 2016 (WWEA, 2010). In this regard, during the past Decade, Iran tried to support the development of renewable energies. Unfortunately, none of the supporting schemes have yielded the desired results. Due to supportive plans, only about 117 megawatts have been installed yet (IRENA, 2015). The total installed capacity of all kinds of renewable energy sources (excluding hydro) has reached to 140 MW (less than 0.5% of the whole country electricity production power). These statistics indicate that there are serious challenges around the renewable energy development in Iran. The need to develop roadmaps, plans and policies to support the development of renewable energy in Iran as a country with a fossil fuels dependent economy, seems vital.

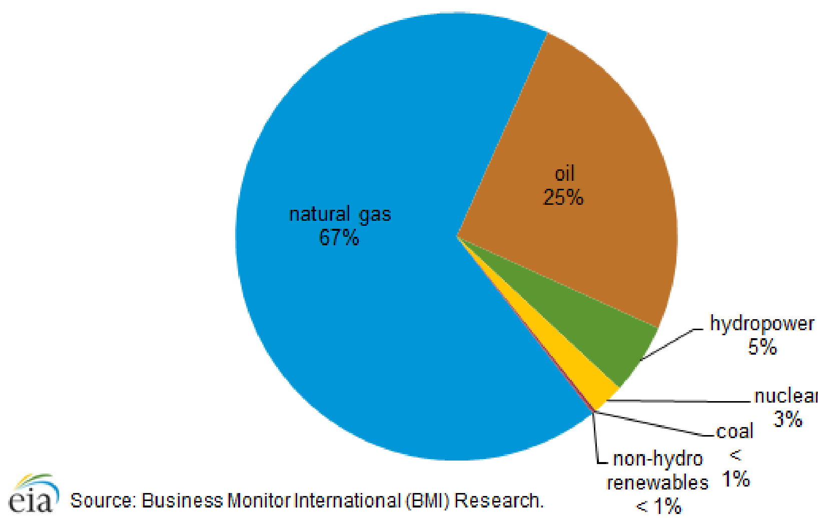

Figure 2. Iran Electrical Energy portfolio (2012)

Supporting mechanisms have many types. The most prevalent ones in the world by 2015 were feed-in tariffs, tendering, and Quota. (Renewables 2015, Global Status Report)

Feed-in Tariff (FiT) refers to the regulatory minimum guaranteed price per KWH that a power utility has to pay to purchase electricity from a renewable power producer. Based on previous studies, FiT is the most beneficial policy for the expansion of renewable energy (Midttun and Gautesen, 2007, Hsu, 2012). FiT provides investors in renewable energy with a long-term, minimum guaranteed price for the electricity they produce. Therefore, it increases their "tendency to invest" by providing a confident degree of financial reliability and reducing the risk of their investment (Lesser and Su, 2008). Keeping that in mind, one can conclude that a considerable budget is required for the governments to adopt the FiT mechanism.

In Iran, it is less than a decade that FiT Policy has been implemented. Since the beginning of 2008, some laws on purchasing renewable electricity were passed, but actually, none of them were effectively pursued and reached their desired goals. In July 2015 with direct supervision of the Energy Minister and SUNA's (Renewable Energy Organization of Iran) president major revisions in organization policies and supporting mechanisms were made and the legislation was notified to the relevant organizations. The most important changes include a declaration of the new FiT scheme with different rates for different types of renewable energy which make attractiveness of investment in renewable energy competitive with investment in fossil based energy production. FiT request approval process time is also reduced to less than a week, and modifications to the organization structure and human resource of SUNA help to actuate such reforms. Also reaching 5GW of renewable installed capacity till 2021 was set again as the renewable energy development target in Iran's sixth development plan. The government expects that the new FiT rates and easy approval procedures can attract enough investors to meet the target.

Although FiT has a number of benefits, it may lead to some drawbacks if it is not applied properly. FiT rates, its degression rates and the period in which FiT policy is applied are the most important factors in the utilization of this policy. The FiT rates must be high enough to recover the investment cost within a reasonable timeframe (Dusonchet and Telaretti, 2010) nonetheless, small enough to avoid enforcing a big financial burden on the states (Rüther and Zilles, 2011). The main objective of this study is to develop a model as a virtual laboratory by which policy makers can assess the effects of different policies and to assist them in implementing more efficient budget management systems toward sustainability in electricity generation. Using this model, policy makers can carry out analyses to forecast the future condition of renewable energies in Iran under different circumstances created by different policies and to determine the suitable amount of FiT rate to be paid for renewable electricity in different periods. The remainder of this paper is as follows: Section 2 provides a review of previous studies. The model structure that consists of sector map, casual-feedback relations, and explanations of system mechanisms are addressed in Section 3. Section 4 presents the simulation results in two different time horizons in order to show the different aspects of a research problem. In Section 5 we provide some policies and choose the best one. Finally, section 6 concludes the paper mentioning some research gaps for future scholars.

2- Literature Review

With respect to the "Evaluation of different FiT policies", the literature is not very rich. A research was carried out in 2014, concentrated on analyzing the long-term FiT policy effect on renewable energy funding in Malaysia (Shahmohammadi et al., 2014). Their SD model contains 5 major parts (cost of electricity generation from renewables, profit of electricity generation from renewables, renewables electricity generation developing process, electricity generation from other resources and renewables development sustainability). They showed by simulation that funding a stock for renewable energy sources shrinks exponentially. Then they did sensitivity analysis for the recommended reduction in FiT rates or increasing surcharges on electricity bills. However, electricity demand could be considered endogenous and investor's trust effects on "willing of investment" also could be mentioned. The latter effect has been found really essential in Iran as a case of current research. Another study about the impact of FiT support policy on renewables development was carried out to calculate the grid parity of different types of renewable energies (Shahmohammadi et al., 2014). Ten different policies of FiT payment were tested and resulted in the fact that higher FiT rates are not necessarily economically feasible. A recently developed Asian country like Taiwan was the case of another research. It is claimed that Taiwan has long-termly aimed to reduce annual GHG emission especially CO_2 and to pay subsidies to investors in renewables as well as effective implementation of FiT mechanism (Wen Hsu, 2012). What they showed is a plenty of chains of reactions and interactions between components of the system that is the reason for using system dynamics in that research. Although FiT has been the most efficient mechanism for renewable energy development in Europe and America, as in 2009, 20 European countries used this mechanism (Campoccia et al., 2009), there was also counterexamples, like Britain. Wen recognized FiT as a two-edged sword that can cause inefficiency in government budget. For implementing this policy, one should consider two things:

1- Motivating the investment and development of renewable energies;
2- Putting obstacles on the way of renewables development due to government incapability of providing adequate budget.

Erik Pruyt developed a SD model in 2007 to capture the dynamics of Euro-25 electricity production sector transition toward a more sustainable energy system. He examined a wide range of policies and scenarios to achieve the optimum multi-dimensional strategy of transition. His SD model was for all energy technologies but he focused on the wind and used the wind-related parameters in the model. Due to believing in existing deep uncertainty in socio-economic systems, Pruyt used multivariate sensitivity analyses to enter uncertainty to the model. Finally, he explained the dynamic complexity and the reaction of the system to miscellaneous policies through the results he achieved.

Lots of research about renewable energy development in Turkey has been carried out like Erturk's study in 2012 that considered many different aspects like geographical, economic and cultural factors for evaluating the development of renewable energies. After the analysis, he concluded that the current FiT rate fields with high wind speed rate (7.5 m/s or more) are economically feasible (Erturk, 2021). In Ukraine a research focused on the flaws and obstacles of implementing FiT policy and finally suggested corrective actions (Trypulska, 2012). Technical issues and government financial affordability for applying such policies for long-term were distinguished as the main challenges in Ukraine. In a more comprehensive research Dasunchet and Telaretti evaluated solar photovoltaic development in all eastern European countries and compared the efficiency of main support policies (FiT, Quota, and renewable energy certificate (REC)) from an economic perspective. They exerted payback period, net present value, cash flow and internal rate of return as criteria for comparison. The results notably showed removing or even amending current policies would considerably affect PV panel market development. (Dasunchet & Telaretti, 2010)

There are a few researches in this field about Iran. A systemic approach by considering five subsystems including government impact, energy market and financial issues, technological development, production barriers and environmental issues was exposed in one of those researches (Hosseini et al., 2012). Two scenarios were applied and tested in this research, with and without support policies and the latter leads to an impressive growth of wind energy by 2015. Not considering the cost of investment and assuming the price and demand exogenously were the research gaps. Some researchers discussed the sustainable development of renewable power generation in rural areas interestingly by a simple system dynamics model. Capturing consumer behavior in the energy sector and distinguishing barriers toward renewable energy development in rural areas of Iran were the main results (Mashayekhi et al., 2010). The model consists of three major loops (two reinforcing: environmental concern, energy cost, and one balancing: knowledge for using) influencing tendency to use renewable energies. Three policies were applied and tested: cultural investment, increase in the fossil prices and improving people's knowledge about renewables. The simulation results showed remarkable renewable's development under each of these three policies. An the weakness? …

3- Model Structure

In this section, we'll vividly represent the model structure by a sector map diagram following with explaining the relative causal loop diagram and its main reinforcing and balancing loops. This model can be used for all kinds of renewable energy technologies. In this paper it has been customized with wind energy specifications. Since historical data are too narrow on the matter of this research due to the fact that these new policies are less than one year old, structural validation has been placed through interviews with some experts of this field and some of the SUNA's managers responsible for renewable energy development. These interviews confirmed the main components, relations and boundary of the proposed model. Also, this model was tested through extreme conditions test. In one extreme condition, electricity consumption as an exogenous variable of the model was set to zero value. It is expected that when the electricity consumption is decreased to zero, the installed capacity would not increase and start to depreciate. Another expectation is that when the tendency to invest decreases to zero, the FiT request would decrease too, even if the relative ROI and social acceptance have positive values. The result of these tests match the expected behavior. Therefore, the confidence in the model structure was raised.

3-1- Sector Map

This diagram gives a holistic view of the model structure so while paying attention to less details, it is possible to get a better understanding of the systematic endogenous perspective of the model. A sector map is basically a rendering of a system at a higher level than the stock-and-flow diagram. (Richmond, 1994). Mashayekhi used the sector map as a device for easing the transition from a mental model of a very complex system to his quite complex stock-and-flow-based rendering of that system(Richmond, 1994).

There are two main sectors: Financial power and renewable development interacting with each other directly and indirectly through Feed-in tariff supporting policy, so that the financial sector is the source of this policy. It triggers self-reinforcing mechanisms in the renewable energy development sector that cause renewable capacity's growth. The first reinforcing loop in the renewable development sector (R1) represents the increasing of renewable energy's prevalence and, therefore, social acceptance and consequently, the tendency to invest in this type of electricity generation technology will increase so that it would bring up more prevalence. There is another reinforcing loop (R2) in this sector that captures the technological learning process effect. More installed renewable capacity means more experience and technological learning creation and less capital cost of installation. Therefore, the share of capital cost in return of investment of renewables will be cut off more so the tendency for investment will rise again and so on. In the financial sector, it has been considered that as government buys electricity generated by renewables, the budget drops and if it couldn't cover payments, tax will compensate. Actually, in interviews, policy makers of the real system didn't mention the increasing tax policy in the budget shortage situation strongly, but an implied mechanism was distinguished in their opinion.

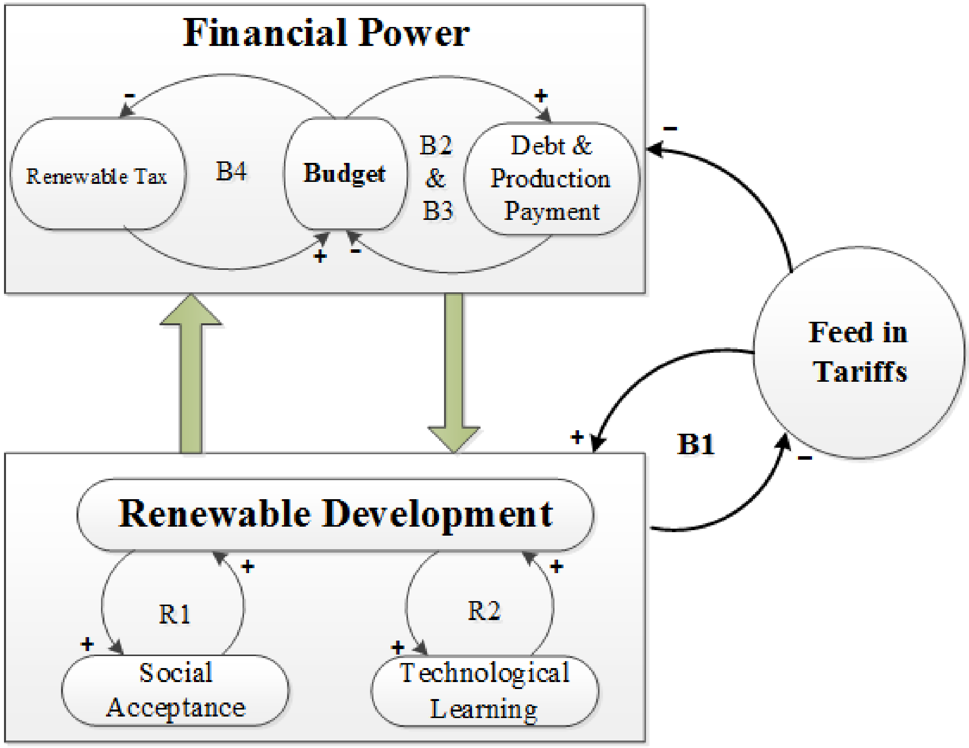

Figure 3. Sector map

3-2- Causal Loop Diagram

The causal loop diagram below shows the all mechanisms inside the system boundary which will be described in details.

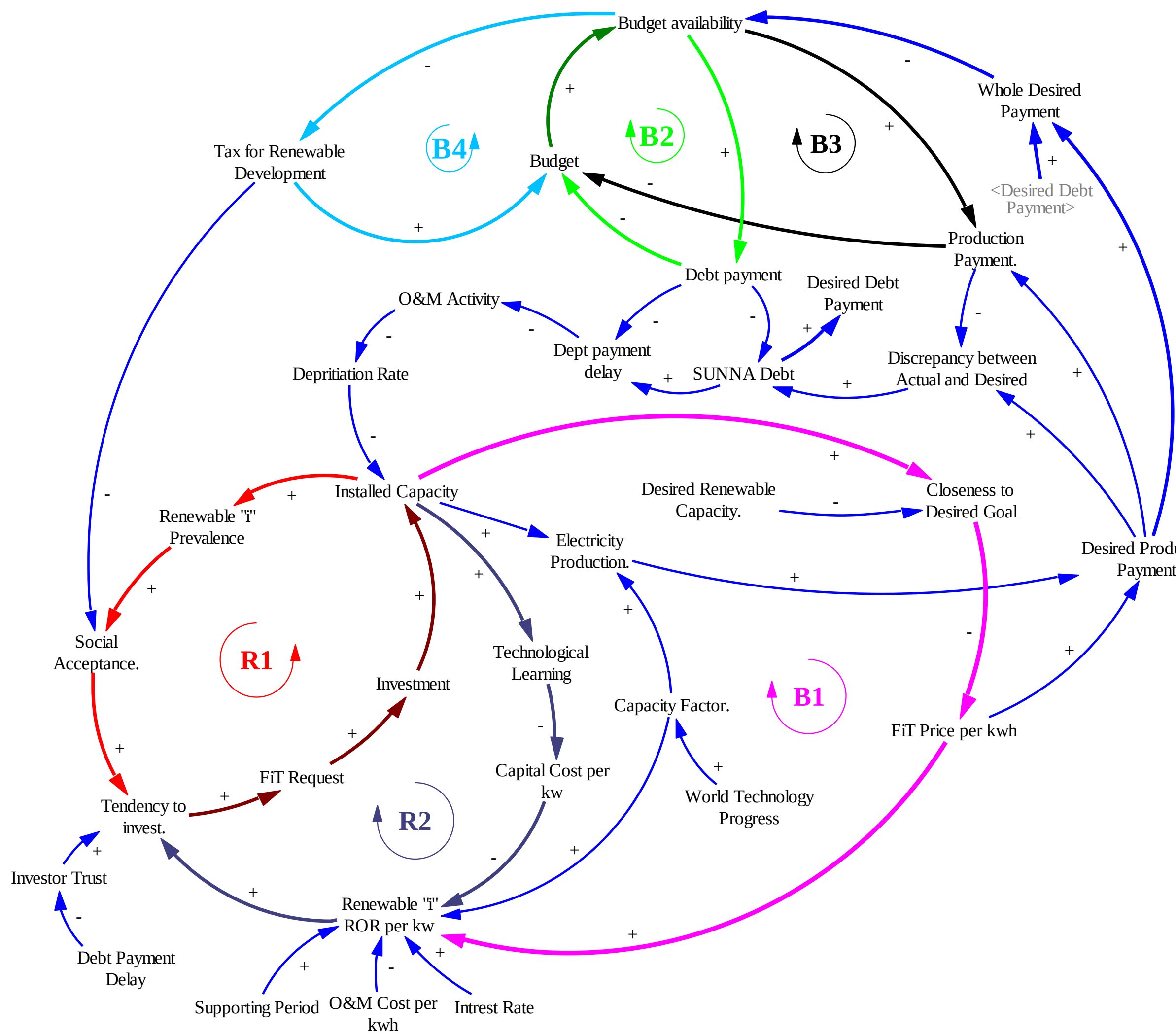

Figure 4. Whole Casual Loop diagram

3-2-1 Social acceptance:

If the investor's trust, social acceptance and the ROI rate of the renewable projects are enough for an investor, the tendency to invest will increase. The tendency to invest triggers FiT requests which leads to investment if approved by the decision makers. Therefore, as the investment increases, more installed plants will accumulate with a constructing delay. So installed plants will drag up the renewable prevalence that causes more social acceptance, more tendency to invest and more FiT requests.

3-2-2 Technological Learning:

As the installed capacity grows, Technological learning and experiencing would take place and it reduces the capital cost gradually based on the learning curve calculated for that specific technology. Therefore, the share of capital cost in ROI will be lower for new investors which means higher ROI and more tendency to invest in that type of renewable source. It also leads to more FiT requests, more investments and more installed plants that trigger this loop for another cycle.

3-2-3 Closeness to goal

This balancing loop indicates that as the installed capacity grows, the distance to the desired goal decreases, which is influencing decision makers directly to lower the FiT rate, which causes a reduction in ROI of renewable project and this -as described above- would lead to less investment, less installed capacity and consequently slows down the process of reaching the desired goal.

3-2-4 Payment:

When renewable electricity producers make their share, the government must keep up with the promise made before and buy their electricity. But it is obvious that the government can pay for something when it has the budget for it. So if the budget amount falls below the amount of the whole desired payment, it causes budget availability to plunge and makes the buyer not capable of paying for production and previous debts which lead to more debts. Also, the amount that the government pays, decrease the available fund and this leads to more budget shortage for the next cycle of B2 and B3 balancing loops.

3-2-5 Tax Balancing:

When budget shortage is perceived by the government, it decides to shift this burden to people and increase the tax for renewable development with the aim of compensating budget shortage. Therefore, it will adjust budget availability again as it can be seen in the balancing loop B4. But as mentioned before, it seems to be a weak feedback from budget availability to renewable tax, because there is no deep consideration of this mechanism in the current policy maker's opinion.

3-2-6 Sociological effect in an energy system

Energy systems are not one-dimensional systems, they are socio-economic systems and there are people in them with a lot of intangible interactions with an economic side. It needs a real systemic view to capture the dynamics of the system. So when the issue is an economic decision and a policy, first of all, this should come to mind what social mechanisms it triggers that would bounce back or enforce the basic economic mechanisms. Some of the decision makers have never even heard of system thinking and the others who have heard, rarely use the System thinking approach principles in the decision and policy-making process.

In this paper, some sociological effects are considered that are rarely mentioned before, even in the literature review section. These are the effects of debt payment delay on investor's trust and O&M activity that renewable power plants owners do, also the effect of tax pricing on social tolerance and social acceptance. The detailed mechanisms will be discussed below.

3-2-6-1 Effect of tax on Social acceptance:

Figure 5: Effect of tax on social acceptance

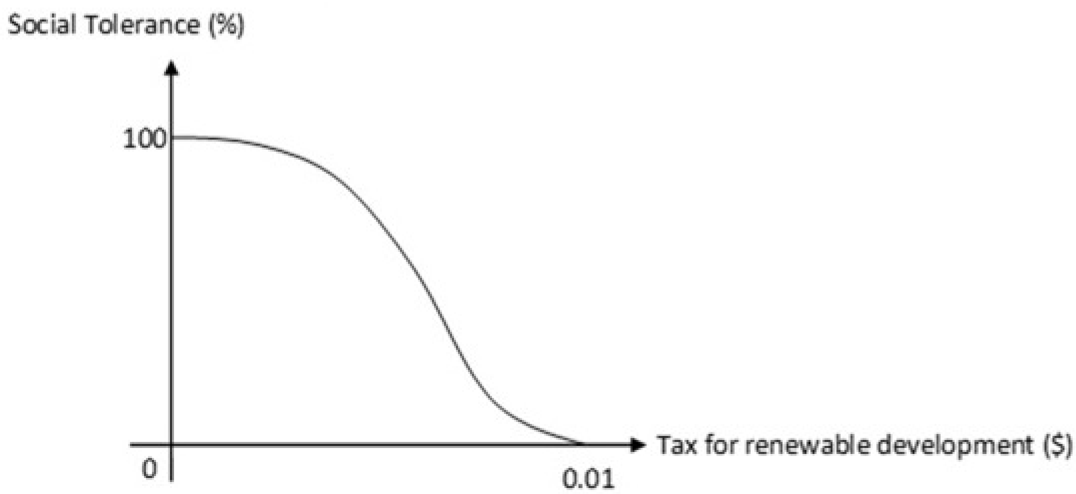

Figure 6: Social tolerance-tax look-up function

As the government increases the tax, it causes the social acceptance to fall through the social tolerance effect which is implemented by a look-up function shown below, then reduced renewable social acceptance will make the investors' tendency for investment to plunge which causes less investment and less installed capacity. Social tolerance represents the reaction of the society to tax pricing. This mechanism means that the policy maker couldn't increase the tax forever because the society has a tolerance threshold and will not be neutral to that.

3-2-6-2 Effect of Debt payment delay on investor trust:

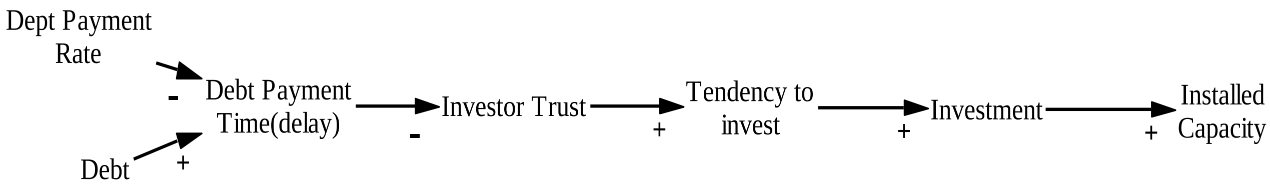

Figure 7. Effect of Debt payment delay on investor trust

When the government should buy electricity produced from renewables and the possible production payment is low, debt takes place. As debt grows and the rate of debt payment falls, the time that the government can pay all debts is lengthened. That is the operational structure which people perceive and react to. As this time becomes longer, it reduces the investor's trust by a look-up function shown below and their tendency to invest follows up which causes the investments and the rate on increase in installed capacity to fall. It is supposed that when the debt payment delay reaches ten years, there would be no trust in a new investor's mind to invest in renewable

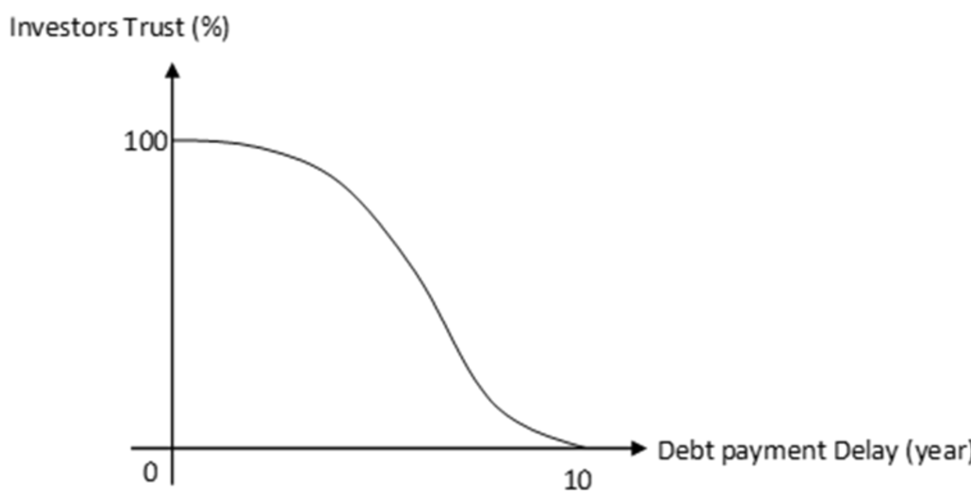

Figure 8. Investors Trust-Debt payment Delay Look-up function

projects.

3-2-6-3 Effect of Debt Payment Delay on O&M activity:

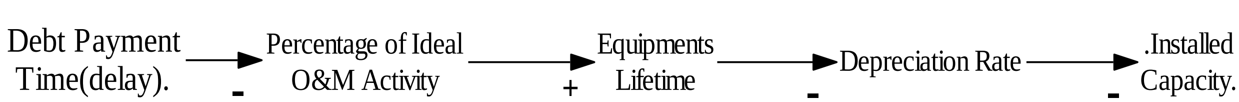

Figure 9. Effect of Debt Payment Delay on O&M activity

In addition to the effect of debt payment delay on investor's trust, this delay also affects the amount of O&M activity each producer does. Because when one producer is not paid on time, it's not rational to shut down the plant and disregard the huge capital cost spent. So he/she would cut off some O&M activity to keep the plant's running costs as low as possible. This effect is considered by a look-up function shown below. While O&M activity decreases over a period of time, the equipment lifetime becomes less and the depreciation rate will rise which will cause more decline in the working installed capacity.

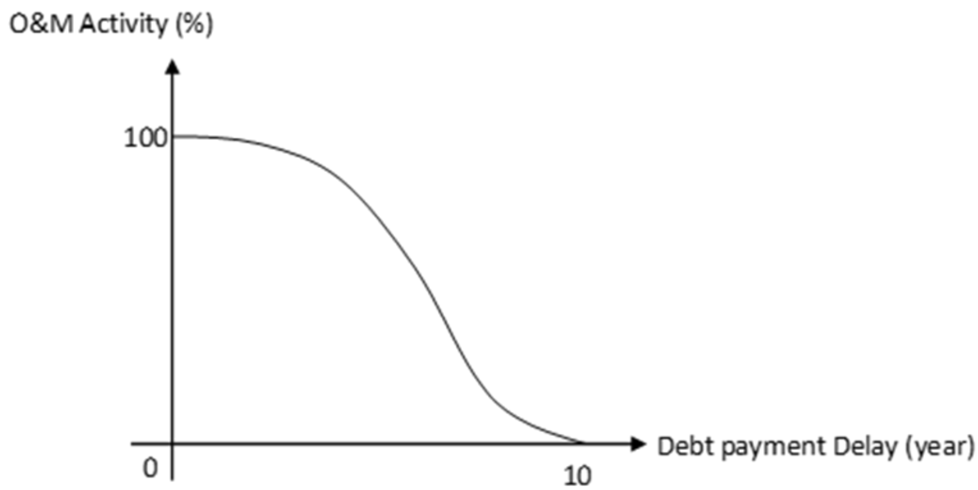

Figure 10. O&M Activity-Debt payment Delay Look-up function

3-2-7 Other:

Electricity production is the result of working installed capacity multiplied by a capacity factor which grows as the world technology progress goes on.

When electricity is produced, it is sold at FiT price ($ per KWH), so desired production payment is made by the multiplication of these two, but as said above, there would be debt if the budget does not cover this year's production payment and the previous debts so by subtracting paid production payment from this desired production payment, the discrepancy between actual and desired one increases the level of debt of this year. Also, the comparison between the whole desired payment and the budget would make budget availability.

4- Results

In this section, we use simulation to analyze the results of the model introduced above.

4-1 Future of renewables in 2021 horizon

Since the government's short-term target is reaching 5,000 MW in 2021, the results of the system's key variables will be demonstrated till the year 2021, first.

Important financial variables are not declaring a bad situation. While debt remains at zero, budget is almost increasing. However, a drop in the last year could be a sign of the switching system's state. But SUNA's debt is zero, and financially, the organization is not facing any problems.

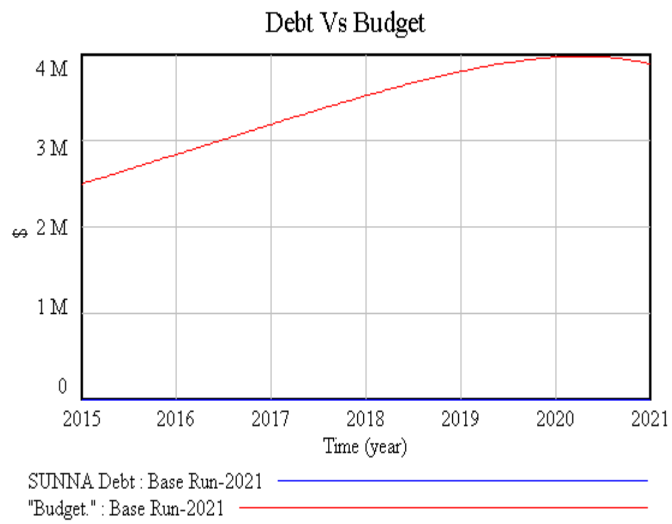

Figure 11. Debt versus Budget simulation result until 2021

Installed capacity will reach 2,300 MW by 2021. Although it's less than half of the desired target, but it has a favorable exponential trend and seems to reach the desired goal in near future.

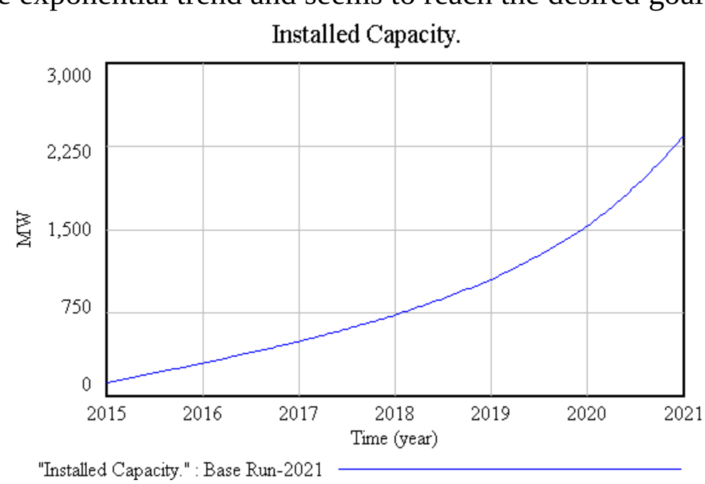

Figure 12: Installed Capacity simulation result until 2021

The tendency to invest that is the main stimulus for the development of renewable energies is growing with an exponential trend and in this interval (6 years) has reached approximately 1.5 times its initial value. This means that in 2021 the amount of requests for investment in renewable energy projects will be 1.5 times of its amount at 2015 that is very desirable.

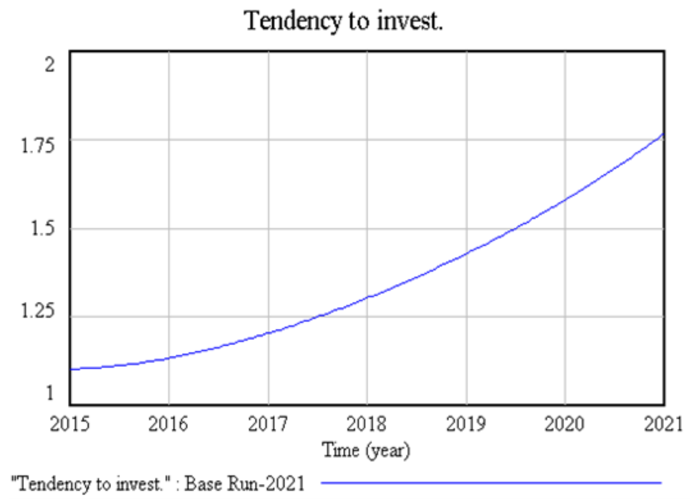

Figure 13. Tendency to invest simulation result until 2021

4-2 Expand the Time Horizon

As described above the system's state looks good till 2021, but one of the most important components of system thinking is thinking along time as Sterman said "System dynamics modelers seek to characterize the problem dynamically, that is as a pattern of behavior, unfolding over time, which shows how the problem arose and how it might evolve in the future" (Sterman, 2000). Expanding the time horizon just a few years, will show the effects of activation of some mechanisms were inactive till 2021.For example trends until 2035, are as follows:

From the year 2024, the problem begins. The debt begins to rise and the budget begins to reduce. So that their difference in the year 2035 would be about 40 million dollars, which means the system will face a severe financial crisis.

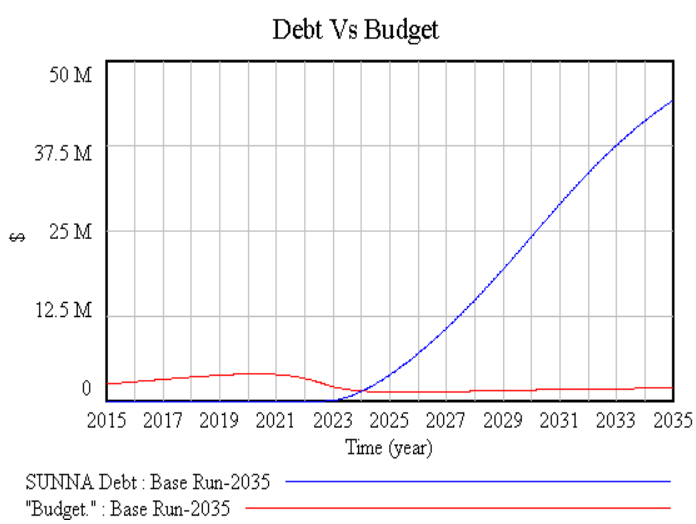

Figure 14. Debt versus Budget simulation result until 2035

Only two years after the year 2021, the installed capacity reaches its preset target of 5,000 MW and until that year, exponential trend is still remained which may confuse decision makers about the system's future behavior. As going further from the year 2021, the behavior is gradually turning into an exponential decay trend (since in the year 2024 that financial crisis begins). After installed capacity reaches about 12,000 MW in 2030, a dramatic decline begins due to the depreciation rate overtaking the construction rate of power plants.

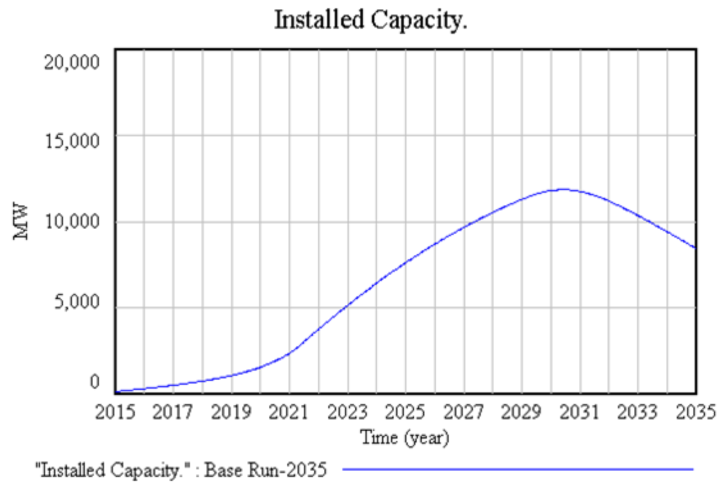

Figure 15. Installed capacity simulation result until 2035

The fraction of the ROI (return on investment) for renewable projects to the average ROI for other projects that is called relative ROI is significantly on the rise. This ratio is one of the key stimuli of the tendency to investment that shows a favorable trend. ROI of renewable projects is on the rise because of the FiT payment increasing and decrease of capital cost due to the learning process. But contrary to expectations, tendency to invest starts declining severely. The reason for this is rooted in the system's financial crisis that will become clearer in the following:

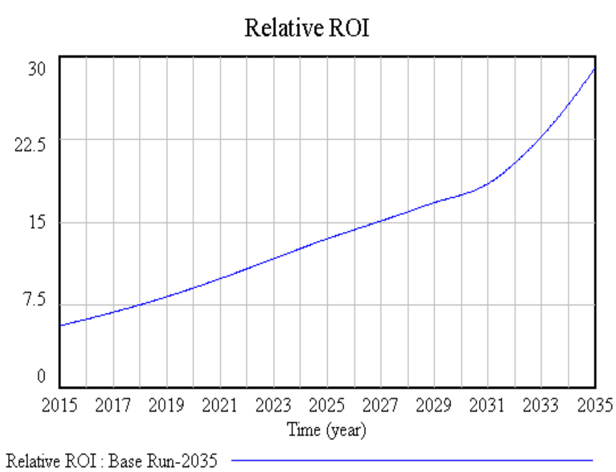

Figure 16. Relative ROI simulation result until 2035

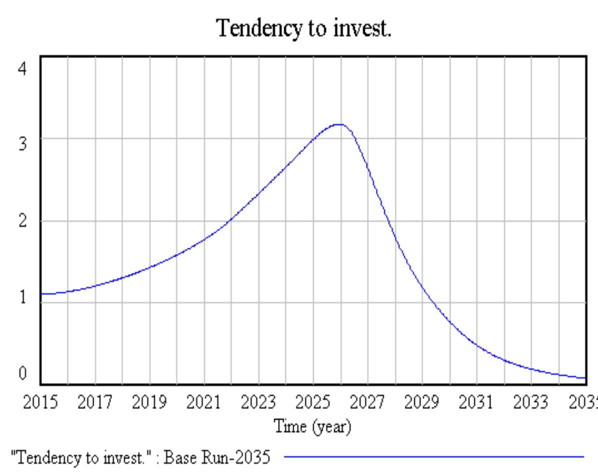

Figure 17. Tendency to invest simulation result until 2035

As the debt increases, the government's payment decreases. Operationally, new investors and existing renewable electricity producers are unaware of the amount of SUNA's debt and budget, but they apprehend the effect of budget shortage and debt increment through delay in debt payments. It can be seen in the graph above until the year 2035, the delay in payments reaches about 23 years. This means that the producer will be paid 23 years later for the electricity generates now. This triggers the sociological effects mentioned before.

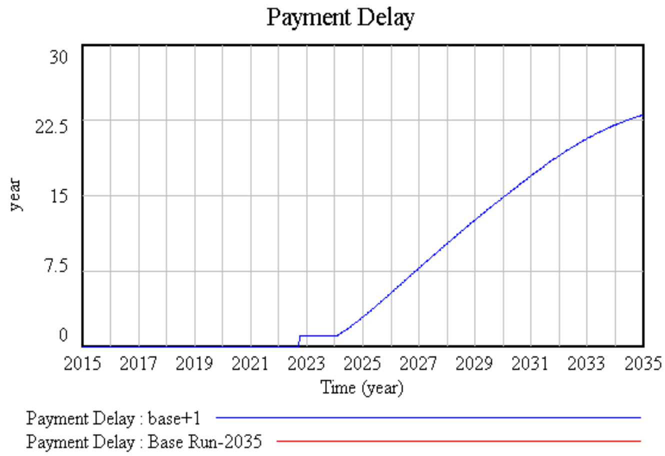

Figure 18. Debt payment Delay simulation result until 2035

As indicated in the graph, approximately 1 year after the financial crisis (the year 2024), due to delays in payment, the investor's trust begins to decline so as in 10 years plunges from 100% to nearly 0%. As a result, new investments which should turn into new installed capacity start a decreasing trend. This indicates that the structure of the model in extreme conditions works well. Because although the relative ROI is increased, but when the investor's trust reaches zero, no matter how attractive that ROI is, the tendency to invest will be zero too.

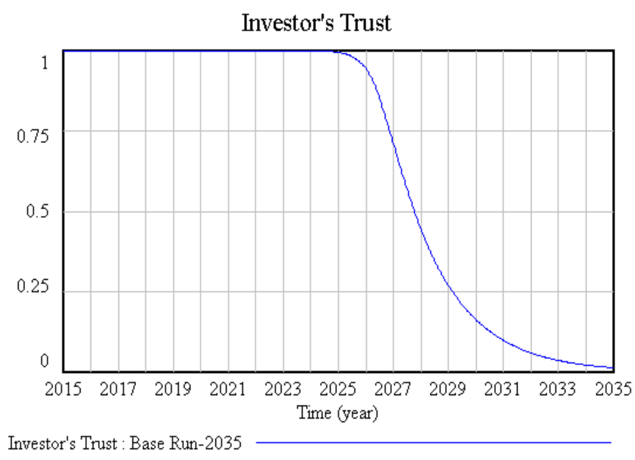

Figure 19. Investors Trust simulation result until 2035

As the delay in payment increases, renewable electricity producers reduce the O&M activities to reduce the costs as far as in the year 2031 that the delay in payment reaches more than 15 years, producers abandon their plant and stop doing O&M activities. The less O&M activity is done, the more equipment depreciation rate is happen, which leads the equipment life to decrease. Therefore, after a while the depreciation rate falls below the rate of construction and as indicated in the Graph above, causes the decline of the installed capacity.

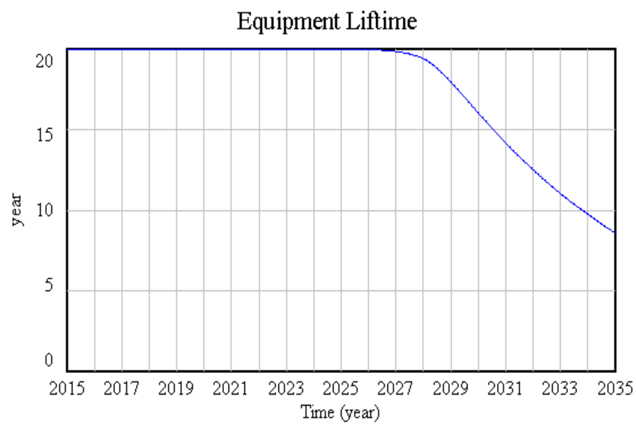

Figure 21: Percentage of Ideal O&M activity simulation result until 2035

5- Policy Implications

In this part, three policies are proposed. The first policy is considered according to a short-term view to the issue, while the two other policies are based on a long-term view toward a sustainable development and taking system feedbacks into account. The Model is simulated after applying each policy and related results are compared and analyzed.

5-1 Policy 1: Increasing the FiT Rate

According to simulation results until the year 2021, perhaps the decision makers decide to increase the FiT rate in order to speed up the development and achieve 5000 MW installed capacity in 2021 as the desired goal. So the amount of 0.03$ increase in FiT rate is considered as the first policy.

5-2 Policy 2: Adjust the FiT rate according to Budget availability

According to the simulation results, it is explicit that the main cause of renewable energy unsustainable development is the financial sector imbalance. Thus, the second policy could be the determination of FiT rates according to the Budget availability. It means that when there is little budget available for a specific year, FiT rates will be announced lower and when the government is financially rich, the higher FiT rates would be announced.

5-3 Policy 3: Adjust the Renewable Tax According to Budget availability

Another suggested policy to resolve the debt problem is getting feedback from budget availability to determine the tax that is taken from electricity consumers. As stated in previous sections, although it has been said that the decision makers would raise the amount of tax in future, but due to the reason that in the year 2015 (which is initial condition for this model) a considerable amount of budget is injected into the system, it did not seem that there would be a problem in the way of the renewable energy development in the future, so adjusting the budget based on the financial situation has not been considered serious. The results of the simulations are shown below:

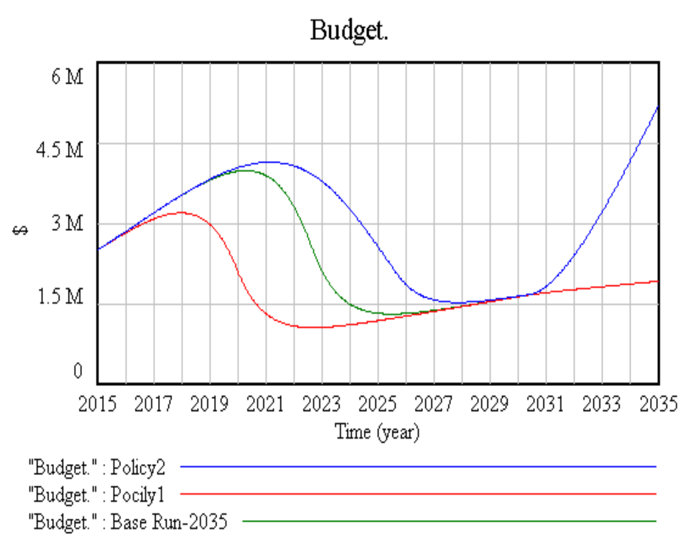

Figure22. Budget simulation result with first and second policy implementations

By applying the first policy, the budget situation becomes worse than the Base Run and falls earlier because allocated higher FiT rates will consume budget earlier (compared to the base run). But the second policy causes budget to fall smoother and later due to the fact that it considers budget situation every time system wants to determine FiT rates. also after a while this policy makes budget increase with more steep because when second policy is applied, very little debt is made compared to base run and it gives the chance to budget to rise again. Budget increases because (1) higher electricity consumption cause more revenues come to the fund for renewable energies Development, (2) as renewable capacity reaches its goal, there is no intention to pay FiT in spite of the fact that budget availability is in a good shape. Increment amount of budget when the third policy is applied is very different from former ones because while the second policy focuses on

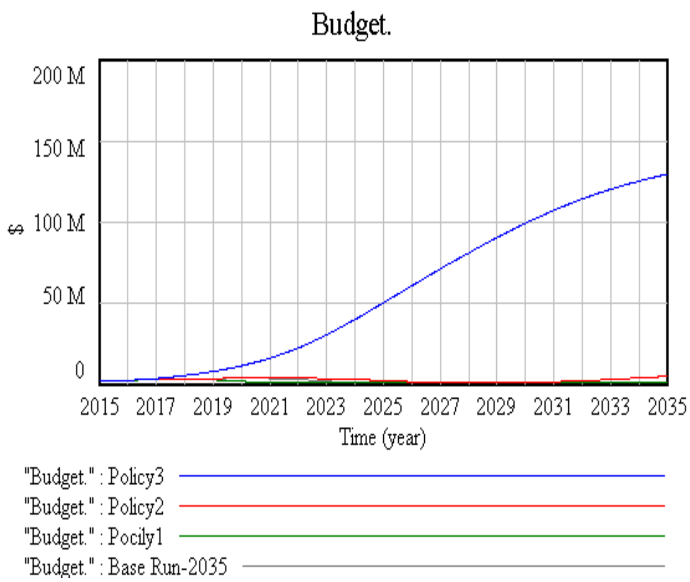

Figure 23: Budget simulation result with all policy implementations

decreasing making debt and keeping decrement rate of budget low, third policy additionally focuses on increasing budget rate by rising tax rate. This difference is shown below explicitly.

As expected, the debt will rise when the first policy is applied. Actually debt reaches its worst-case up to $52 million which is approximately $6 million more than the base run case. When the second policy is applied, in 2009 a small amount of about $1 million debt will happen which is compensated by budget in the next year. Despite considering budget availability for determining FiT rates, there is debt because of delays in the system start from the moment budget shortage is perceived and then creates signals to decrease FiT rate. When the third policy is applied, there would be no debt because the budget shortage would never happen.

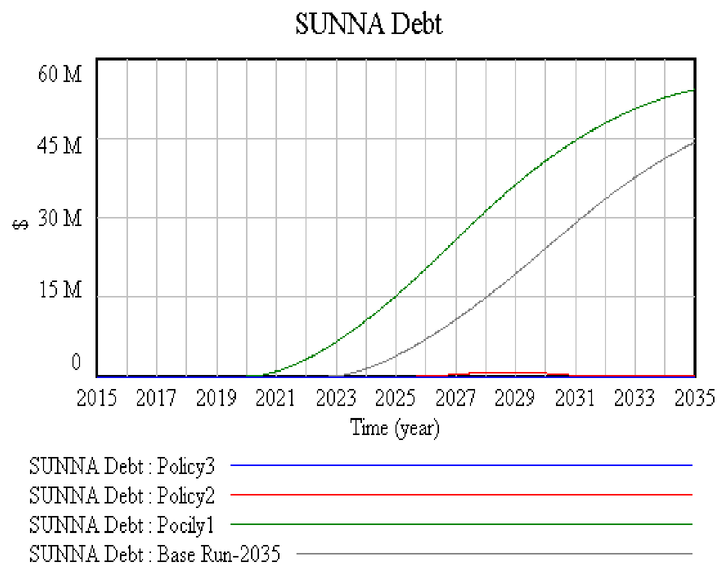

Figure 24. SUNA Debt simulation result with all policy implementations

In the installed capacity diagram that represents development process, the difference between

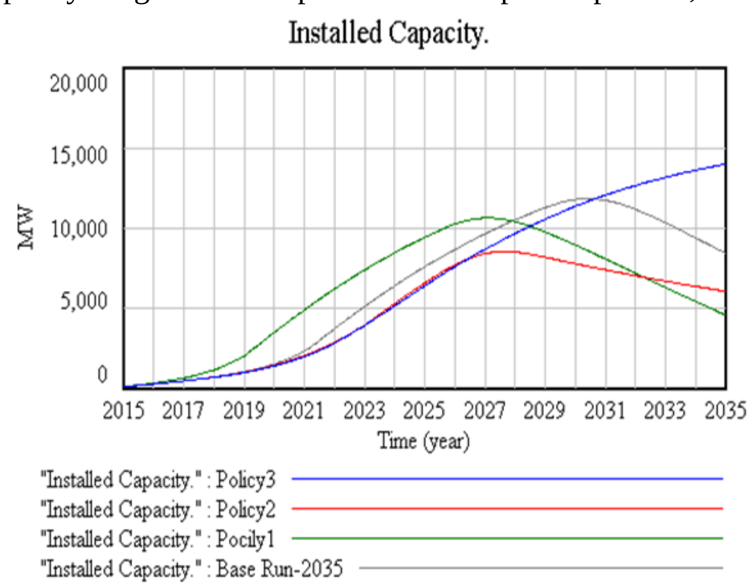

Figure 25: Installed Capacity simulation result with all policy implementations

applying each policy is well shown. When the first policy is applied, installed capacity reaches to 5,000 MW by the year 2021 and if the decision makers do not apply the systematic approach, they would adopt this policy. As it is clear, this policy will fail the system sooner than all other policies and the installed capacity after 2027, will face with a rapid drop. With applying the second policy, although installed capacity grows slower, but because of taking feedback from the budget availability, that rapid drop in the base run would not happen, and it follows a more stable trend. In addition, due to the budget increasing that occurs in the year 2031, if the simulation duration increases, the stated drop will be even less. Installed capacity has not fallen when the third policy is applied and follows a favorable trend, although it would take off later than in the base run.

The tendency to invest, which is the main stimulus for renewable energy development as the first policy is applied, would behave much the same as the base run but sooner reaches nearly zero. Second policy inefficiency can be seen here very explicitly because the tendency to invest start to fall and reaches a bit below zero and then rises a little. The negative value for tendency to invest is interpreted as the negative viewpoint of investors about renewable projects that leads to zero FiT request in the model. This indicates that second policy is good just for the financial sector. By applying second policy and reducing FiT rates, the financial crisis will be stopped, but on the other hand, it means reducing ROI of renewable energy investments which leads investment attractiveness to fall and this will reduce the tendency to invest. But third policy shows a favorable trend and increases the willingness to invest up to 5 times by the year 2035, although compared to behavior of system under applying the other policies, tendency to invest begins to rise later and remains constant about 10 years. Applying Third policy prevents debt creation, consequently do not influence investors' trust, also help the learning process to decrease the capital cost and this increases the ROI. But the reason why the tendency to invest start to increase with a delay, in this case, is rooted in rising taxes and reduced social acceptance in the early years of implementing this

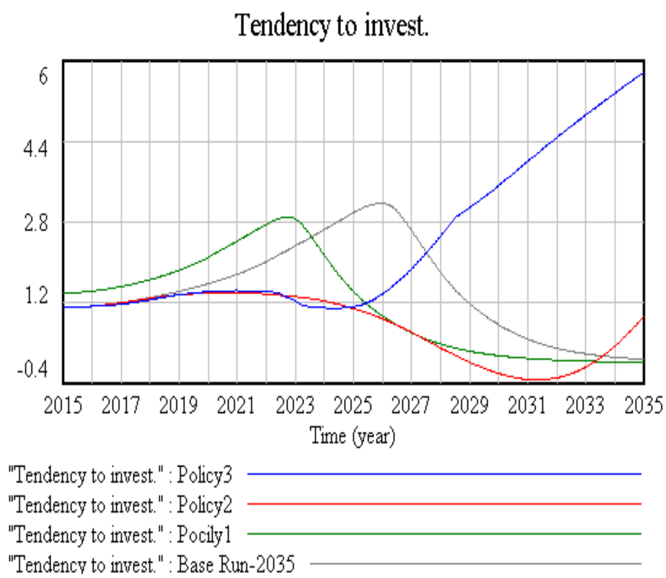

Figure 26. Tendency to invest simulation result with all policy implementations

policy.

Tax increases due to fact that the third policy is applied to avoid debt and to increase in the budget so that the development of renewable energy is assured and decision makers are not forced to reduce the FiT rates, which makes sudden decline in the social acceptance in early years. But when the budget reaches to the amount that would be enough for installed capacity to take off, and the reinforcing loops effect get stronger constantly, the tax gradually reduces and the social acceptance begins to rise leading to the rising of tendency to invest sequentially.

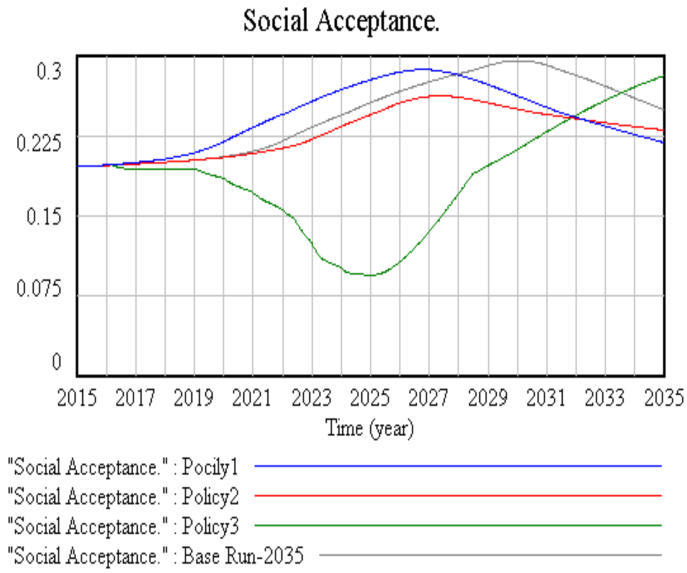

Figure 27. Social Acceptance simulation result with all policy implementations

5-4 Best Policy

According to the analysis of each 3 policies, the third policy is the best of given ones because it not only prevents debt for SUNA and prevent psychological effects caused by debt but also assures sustainable development of renewable energies, reaching up to the amount of 15,000 MW in the year 2035.

6- Conclusion and Future Research

Iran's share in GHG emissions and global warming, air pollution, energy security, and passive defense requirements are some of the important energy-related challenges in the country. Development of renewable energies is one of the most effective solutions to deal with these challenges. Despite scattered efforts has been made in recent decades, renewable energy situation in Iran is not desirable. Therefore, in mid-2015 the government has implemented FiT supporting policy as one of the most widely used policies to develop renewable energies around the world. Based on the literature review and experience of leading countries in this field, the most important issue in FiT policy implementation was diagnosed financing that if it is not well-managed not only it would be possible to risk the development of renewable energy but also to cause financial crises.

By studying the implementation of this supporting policy mechanism and recognizing the situation in Iran, our dynamic hypothesis was created. We exposed that after a temporary and sectional growth of renewable energies, they will have trouble with financing so that the sustainable development of renewable energies will not happen. To test this hypothesis, we proposed a SD model that has two main sectors; financial and development sectors which FiT policy acted as an intermediary between these two. With an innovative view, we considered social reactions to economic mechanisms and financial conditions in the system in the form of sociological effects: the threshold of social tolerance and social acceptance, investors trust and percentage of doing O&M activities.

The base model simulation results proved our hypothesis and showed that although shortly after the implementation of the FiT mechanism, there will be a growing exponential trend, but this temporary development period is due to the amount of initial funding that had been allocated to the system.

Due to the inefficiency of financial sector, after a while, debt began to increase and through different mechanisms caused troubles to the development of renewable energy installed capacity. To deal with this challenge, three policies are proposed and the results are analyzed. Getting feedback from budget availability for tax adjusting is diagnosed the best policy which would lead to renewable energies sustainable development without any financial crisis.

Future studies may consider the issue of competition between different types of renewable energies. Also considering electricity demand and effects of increasing energy prices and taxes on electricity consumption as endogenous mechanisms can make the model closer to the real world.

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Appendix I: Stock-Flow diagram