A Technological Innovation Systems Analysis Of The Renewable Energy Technologies Under The Feed-In-Tariff Program

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Abstract

The Renewable Energy Act of 2008, through the National Renewable Energy Program (NREP), has increased the development of Renewable Energy sources (solar, hydro, wind, geothermal and biomass). Tax holidays and the Feed-in-Tariff (FIT) have encouraged this development. The FIT in particular is controversial as it compels electricity consumers to pay more in order to guarantee a fixed payment for the generation of Renewable Energy (RE) at rates that are currently more expensive than the average market rate for electricity. In the country at present the covered RE production constitutes a small percentage of total energy production. Consequently its immediate projected contribution to the electricity rate is still small. But this will increase as more energy producers are attracted by the incentives and the percentage of RE contribution grows. This research will analyze the local Technological Innovation System (TIS) for the core technology of each renewable energy resource covered in the FIT program. The goal is to identifying any potential pitfall and to find a way to foster design and development, and manufacturing capability build-up using the framework.

Keywords- Technological Innovation System, Renewable Energy Technologies, Feed-In-Tariff natural Renewable Energy Programs.
Introduction
The Renewable Energy Act of 2008 (RA 9513), through the National Renewable Energy Program (NREP), has increased the development of Renewable Energy sources (hydro, wind, geothermal and biomass). Tax holidays and the Feed-in-Tariff (FIT) have encouraged this development. The FIT, in particular, is controversial as it compels electricity consumers to pay more in order to guarantee a fixed payment for the generation of Renewable Energy (RE). The FIT rates are currently more expensive than the average market rate for electricity. In the country at present the covered RE production constitutes a small percentage of total energy production, so immediate projected contribution to the electricity rate is still small. However, this will increase as the percentage of RE contribution grows as more energy producers are attracted by the incentives. In fact, in Germany and in many other countries that have increased their portfolio of RE, the average electricity rate has increased. Germany, one of the biggest economies in the world, can afford spending more for RE production. But it remains to be seen how the FIT will affect the already high electricity rates in the Philippines. Record low prices of oil all but guarantee that fossil fuel energy will be very cheap for a few more years. Although RE lessens the country’s dependence on foreign fossil fuels in the long term, in the short term it adds to consumers’ electricity prices. For as long as oil and coal are cheaper than RE, the Philippine consumers will have to pay more for RE.

The government (through tax holidays) and consumers are already spending money on RE, therefore the country should seek to gain more in return for its “investment”. That is for the country (the government?) to gain economically from RE as producer and designer of its technology. This is also one of the goals of the National Renewable Energy Program, but not much attention is being paid to it now. This research will analyze the local Technological Innovation System (TIS) for the core technology of each renewable energy resource covered in the FIT program. The goal is to identify any potential pitfall and to find a way to foster design and development, and manufacturing capability build-up, using the framework (see below).

THE THEORETICAL FRAMEWORK
The theoretical framework used in this study is the Technological Innovation Systems framework developed by Hekkert et al with inputs from the resource based view framework devised by Markard and Worch.

The TIS consists of actors or the players, and institutions or the rules within the framework. The actors are the active participants, organizations and individuals, in the structure; while the institutions are the incentives for the actors to do things a certain way within the system.

By using a technological innovation system, as opposed to a national innovation system, the flows of effect and causation are more easily comprehensible as they pertain to a specific technology rather than to all the technologies within a country. A resource based view on why individual organizations participate or not in the IS can even be employed insofar as the more limited scope of a TIS framework allows it.
A TIS is primarily analyzed using its system functions. These are events or activities that drive the development of the TIS. These activities are categorized into seven functions by Hekkert et al.

7.1 F1 ENTREPRENEURIAL ACTIVITY
These are the activities undertaken by the industry actors in the TIS, and how they develop and/or manufacture products and services that use the covered technology.

7.2 F2 KNOWLEDGE DEVELOPMENT
These are classified into three categories: learning by searching, learning by doing and learning by using. Learning by searching refers to both basic and applied research on the technology. It might cover new discoveries or the application of methods from other technologies to the covered technology. It is the knowledge that improves the performance and that influences the attributes and design of the technology. Learning by doing can emanate from academe and public or private researchers. Learning by doing pertains to the process technology of manufacturing the productized version of the technology. This includes the efficiency and resulting production increase and cost savings developed when mass producing a product. Learning by using refers to learning gained by using the products. This might develop insights on better use of the product which is vital to the overall development and diffusion of the technology.

7.3 F3 KNOWLEDGE DIFFUSION
This is the transfer of knowledge, explicitly or implicitly, from one organization to another via networks that share whether these networks are geographical, industry-related or technology related. This can be the “free” knowledge passed around in conferences or through chance meetings in the area. Or it can be knowledge paid for through joint-ventures, alliances or by other formal means within the same country or facilitated by one country for another. This is important to drive the direction of the technology and to build the technology as well as to simply gain knowledge.

7.4 F4 GUIDANCE OF THE SEARCH
These are the expectations built around the technology, whether prompted by government incentives, or driven by the media, or by the industry. This determines the direction of the technology and how fast and how much a technology is developed and diffused.

7.5 F5 MARKET FORMATION
A technology should have a market so it can thrive. In the end it is the market that determines whether a technology is diffused or not. Incentives and government regulation can initially create a niche market but eventually actual demand for the technology, whether legislated or not, determines its success.

7.6 F6 MOBILIZATION OF RESOURCES
The mobilization of physical, financial, infrastructural and human resources is needed
to develop and mass produce the technology. A lack in an irreplaceable resource will doom the development of that technology.

7.7 **F7 ADVOCACY COALITIONS**

New technologies will always encounter resistance from the status quo. It is up to the lobbyists for the technology (who may be from but are not limited to the technology developing organizations themselves) to push the technology to the market and more importantly to the government, as it is the government which has the capability to legislate initial niche demand for the technology. Lack of push for the technology can foreclose its development. But an overaggressive push for it might turn off the market as well.

7.8 **BUILT-UP OF VIRTUOUS AND VICIOUS CYCLES**

System functions are designed to be analyzed in terms of how they affect each other. This series of effects can be positive, building up on each other and fostering TIS growth. Or it can be negative; pushing each system function in a downward spiral that effectively kills or weakens the TIS.

It is important in TIS analysis to identify which system functions drive the cycles forward. Policies and recommendations can be focused on the important system function to push it to develop. On the other hand, it is vital to know which system function can push the TIS down a vicious cycle. It is imperative to create plans to mitigate and minimize the vicious cycle or to monitor it and to nip any emerging negative trend in the bud.

Virtuous and vicious cycles usually alternate. At times the development of the performance of a technology and its market diffusion might lie within the same cycles. For example, an import ban on competing technologies might for a time increase the market diffusion of a product in a country, a virtuous cycle, but at the same time the guaranteed market might stagnate the development of its performance parameters.

![Figure 1 Virtuous cycle of system functions](image-url)
METHODOLOGY
In this paper the core technology of each renewable energy resource covered in the Feed-in-Tariff (FIT) scheme of the government will be identified. The core technology has the highest value added component or the component which gives most financial value for its design and development. These core technologies are: photovoltaic cells for solar power, hydro turbines for hydro power, and wind turbines for wind power. In the course of analysis the cogeneration facility was identified as most vital technology for biomass power.
This research gathered all pertinent events per system function using the internet. The general direction of the system function, whether positive or negative, was also analyzed.
F1 entrepreneurial activities were drawn from the FIT approved projects by the Department of Energy (DOE). Recent press releases of potential new players were also referenced.
F2 knowledge development was drawn from a number of published papers in the SCOPUS index. Keywords used were: “photovoltaic” for photovoltaic, “wind” and “turbine” for wind turbines, “hydro” and “turbine” for hydro turbines, and “biomass” and (“power” OR “energy”) for biomass technologies. The number of researches was compared with those of neighboring countries Indonesia and Malaysia to rate the absorptive capacity and knowledge development activity of the technology. The increase or decrease in researches over time was noted.
Local manufacturing capability for the technologies was also examined as manufacturing capability is the next high-value activity, after design and development. Installation of the technology was also probed to gauge the interest of the local actors in learning to develop the energy production facilities for each facility.
F3 knowledge diffusion was gauged by tracking the number of researches from SCOPUS co-authored with foreign institutions. Activities to transfer knowledge of the technology from other countries were also checked. Efforts by the government to transfer knowledge of the technology to local players were also monitored. The joint-ventures of local companies with foreign companies were also noted. However, as these joint-ventures are still new, it is difficult to determine whether local companies have the intention of learning the technology from the foreign partner.
F4 guidance of the search was gauged by determining the number of new projects approved for FIT and the number of announcements of interest made within the current year 2015. These formed the basis to gauge the desire of players to embark on renewable energy (RE) projects. Any recent strong backlash was also searched in the internet.
F5 market formation was tracked by monitoring the FIT requirement, how much of it was being met and whether the requirement was increased. Any publicized request to increase it further was also noted.
F6 mobilization of resources was gauged by checking on any publicized impediment financing-wise or raw material-wise for the projects. Participation by big foreign players was also noted as they bring in bigger financing.
F7 advocacy coalitions were measured by how much the industry actors or any other private or non-governmental organizations were able influence the government to
increase incentives for their own sector, particularly in increasing their FIT requirement.
After checking each system function, the vital system functions were identified and directionally linked together in terms of how they are bringing or can bring more diffusion of the technology, and how these can be used to encourage design and development, and manufacturing capability build-up for each core technology locally. Also examined were the potential vicious cycles that would follow if the status quo remains of having no technological capability build-up agenda.
A recommendation was made in terms of tweaking the current system function driven cycles to foster design and development, and manufacturing capability build-up for each core technology. Specific policy recommendations adapted from the current FIT scheme were forwarded.

9. ANALYSIS OF PHOTOVOLTAIC, HYDRO, AND WIND TURBINE, AND BIOMASS TECHNOLOGIES TECHNOLOGIES IN THE PHILIPPINES
9.1 PHOTOVOLTAIC CELL TECHNOLOGY
9.1.1 BACKGROUND OF SOLAR POWER AND PHOTOVOLTAIC CELLS IN THE PHILIPPINES
The first on-grid PV cell power plant in the Philippines was installed by CEPALCO in 2004. Prior to this all solar power installations in the country were in off-grid areas. In that same year, SunPower, a US-based solar panel maker, established its solar panel manufacturing plant in the Philippines. To date, Sun Power remains the only on-grid PV manufacturer in the country.
Since the approval of the Feed-in-Tariff in 2014, the installation of solar power plants has dramatically increased. At the same time the relative drop in solar panel prices and the implementation of Net Metering and the Peak/Off-peak Power of Meralco since 2013 have made possible the installation of solar panels in households. This has led to the creation of SMEs that retail and install solar power panels.
A new company, Solar Philippines, installs solar panels in shopping mall rooftops. A recent joint-venture with Citicore Power makes it potentially one of the bigger players in this young industry.
The major energy players are also joining in the solar power industry. Aboitiz has joined up with the US solar power company, SunEdison, to build solar power plants in the Philippines.
In spite of the growth of solar energy projects there is scant research on photovoltaics in the country. There is no move to bring in more PV manufacturing locally. It seems local solar energy stakeholders have no plans to develop or manufacture PV cells locally; instead they are sourced mostly from outside.

SYSTEM FUNCTIONS
1.1.1.1 FI ENTREPRENEURIAL ACTIVITY
Large companies and SMEs are flocking to the solar power industry; and many projects both for personal and public use have been approved for 2015. The largest
players are: Solar Philippines and Citicore Power (planned: 300 MW); Aboitiz and SunEdison (planned: 100 MW).

1.1.1.2 F2 KNOWLEDGE DEVELOPMENT
There is limited research on photovoltaics in the country, only 17 since 2000. Although the number of researches seems to be increasing, it is still small compared with our neighbors Indonesia (120) and Malaysia (978). This scant research activity on photovoltaic indicates a low absorptive capacity in photovoltaic technology in the country compared with our neighbors. Consequently Indonesia and Malaysia have locally published journals cited in the Scopus index. It is possible that there is a lack of Scopus indexed local engineering and science journals; or that local journals do not publish as much research on renewable energy technologies. Whatever the case this lack in local publications also contributes, although on a smaller scale, to the lack of published researches in renewable energy technologies in the country.

![Documents by year](image)

Figure 9.1 Number of published papers on photovoltaic technology in the Philippines†

On manufacturing, although there is a PV manufacturing facility in the Philippines, it is owned by a US company. There is no evidence that this facility is diffusing technology locally to its employees. With the heavy activity in the installation of solar power plants, there will surely be development in knowledge on this front.

1.1.1.1 F3 KNOWLEDGE DIFFUSION
Some researches on photovoltaics were undertaken in collaboration with foreign universities. But the researches done locally by foreign private companies were not undertaken in collaboration with local universities. There are no known networks that transfer knowledge in photovoltaic development and manufacturing locally. As for

† www.scopus.com
installation, joint-ventures with bigger foreign companies might facilitate some knowledge diffusion.

1.1.1.2 F4 GUIDANCE OF THE SEARCH
There is great momentum now in building solar energy projects. The large foreign solar companies, such as First Solar, are trying to join in. Although it is unclear whether the government will expand the FIT capacity for solar power beyond the current 500 MW requirement, industry players seem to be bullish that it will. Currently there are already 3000 MWs worth of projects vying for eligibility for the 500 MW requirement.

1.1.1.3 F5 MARKET FORMATION
On account of the FIT approved solar energy producers are guaranteed a fixed rate for 20 years for electricity production. These guaranteed rates are: P9.68 per kWh for the first 70 MW of the FIT; and P8.69 per kWh for the next 71 MW to 500 MW. In comparison Meralco charges P4.81 per kWh for electricity as of May 2015. It is still unclear whether the government will increase the FIT capacity and at what rate.

1.1.1.4 F6 MOBILIZATION OF RESOURCES
There is clearly no lack in resource in building solar power plants. However, the scant research in photovoltaics indicates a possible lack in financing and researchers. Although the RE law provides for a trust fund to finance research and development (RND) in renewable energy, it is unclear how much is going into this trust fund, if any; and whether there are any renewable RND projects in the pipeline.

1.1.1.5 F7 ADVOCACY COALITION
The solar companies seem to have clout in terms of having the FIT requirement increased. Barely a year after a 50 MW requirement for solar was set in April 2014, this was raised to 500 MW in April 2015. However there seems to be no voice lobbying for local photovoltaic development and manufacturing.

1.1.2 VIRTUOUS AND VICIOUS CYCLE
1.1.2.2 VIRTUOUS CYCLE
As mandated by the Renewable Energy Act of 2008, the NREB has set the FIT guaranteeing profitable energy rates for solar energy providers (F4)(F5). This led to the formation of new solar power companies, joint-ventures and solar energy activities from established energy companies (F1) that quickly met the initial 50 MW requirement. The solar companies lobbied for the requirement to be increased to 500 MW (F7) and they were accommodated by the government. This increase in requirement (F5) has brought in the big players of the solar power industry (F6), all of which are putting pressure on the government to increase the FIT requirement for solar.

However, left out in the virtuous cycle is the development and diffusion of knowledge. There is little research on photovoltaic in the country. There is no local manufacturer of photovoltaic cells, except the subsidiary of a foreign company. There
is neither knowledge development nor diffusion in photovoltaic cell development and manufacturing. The only knowledge gained is that of installing photovoltaic cells whose value-added is markedly lower than developing and manufacturing photovoltaic cells.

The government, through its tax holidays, and consumers, through the FIT, are essentially funding the development of solar power plants with no immediate economic benefits to both government and consumers. Any increase in the solar energy FIT requirement will mean more expensive electricity for consumers. Employment gains from the construction of solar power plants are temporary, coming to a halt once the FIT requirement is not increased. Employment in services for installing household solar power panels will be retained but that is just a small number compared with job creation if the country were to manufacture photovoltaic cells. But the best economic gain would be if the country developed and designed its own photovoltaic cells. Then local companies could gain the highest value-added chain in the solar power industry.

1.1.2.3 Vicious Cycle
The current lobbying to expand the solar power FIT requirement may cause a negative backlash from the public if accommodated. The projected energy demand by 2030 is 29330 MW. It was at 17585 MW as of March 2015. Already 500 MW of the projected demand will be filled by solar which is twice more expensive than the market rate. Fossil-fuel prices are not expected to significantly rise soon. So any increase in the solar energy FIT requirement will saddle the consumers, excluding the transmission and other charges, with twice the cost compared with fossil-fuel sources. The projected installed capacity by 2030 is about 4500 MW less than the projected demand. Meralco started its FIT charge with a rate of P0.04/kWh. This is still a low value but it is not inconceivable that the solar companies will lobby to increase the solar energy FIT requirement to close this amount. If this happens and electricity prices increase significantly, there will probably be a terrible backlash against solar energy (F4). The government will be forced to backtrack on this and the local companies will scale down their activities (F1) and happily live off their guaranteed energy rates. The consumers will be saddled with higher electricity prices. The country as a whole will have nothing to show for its support of solar energy: no photovoltaic manufacturing sector, no local high-value added photovoltaic development and design companies.

1.2 Hydro Turbine Technology
1.2.1 Background of Hydro Power and Hydro Turbines in the Philippines
The Philippines has a long history of using hydroelectric power starting in the 1940s. It is still the largest renewable energy source in the country by a large margin (63% as of 2010).
However, the building of hydroelectric dams entails large financing and causes the displacement of indigenous upland settlers. For this reason the cheaper mini-hydro and smaller capacity projects (with smaller ecological footprints) were encouraged by the government to serve both on-grid and off-grid sites. The Mini-Hydro Act of 1991 was the first law to incentivize building these projects. It has since been upgraded by the Renewable Energy Act of 2008.

The Mini-Hydro act provides tax credits to buyers of locally manufactured turbines. But these incentive seems to be moot because the importation of foreign equipment is already tax-free.

The DOE attempted to support the development of the local turbine manufacturing sector by providing training and standard testing in coordination with De La Salle University and Japan International Cooperation Agency. However, this seems to have largely failed as there are few turbine local manufacturers yielded by this research. Notably the bigger and better publicized mini-hydro projects use foreign turbines.

The installation of mini-hydro power plants is supported by the incentives and fixed rate provided in the RE act of 2008. The FIT requirement set by NREB for mini-hydro is at P5.90/kWh for 250 MW.

1.2.2 SYSTEM FUNCTIONS
1.2.2.2 F1 ENTREPRENEURIAL ACTIVITY
As with solar, the RE Act of 2008 has encouraged a lot of activity in mini-hydro (101 KW to 10 MW). The leaders are: Hedcor of the Aboitiz group and First Gen of the Lopez group.
There is very limited activity in the manufacturing of hydro turbines in the country.

1.2.2.3 F2 KNOWLEDGE DEVELOPMENT
There is little research on hydro turbines in the country, only two in fact. Similarly, and compared to photovoltaic, our neighbors have few researches on hydro turbines: Indonesia (20) and Malaysia (30). It is possible that the amount of affordable research on hydro turbines is limited. However this means that it is unlikely that a better hydro turbine design can be developed locally.

1.2.2.4 F3 KNOWLEDGE DIFFUSION
Although there were initial training programs conducted by De La Salle University for the manufacture of hydro turbines there seems to have been no follow-up after 2004.

1.2.2.5 F4 GUIDANCE OF THE SEARCH
The RE Act of 2008 has increased the interest in mini-hydro. Although not covered with incentives there seems to be renewed interest in developing the large-scale hydro power plants as well. However, given the scale of the projects, there is a need to ensure that no indigenous settlers are displaced and/or to mitigate adverse effects on them.
Although on paper the government has supported the manufacture of hydro turbines, this seems to have been half-hearted as the training programs and quality standard testing activities were not sustained.

1.2.2.6 F5 MARKET FORMATION
There is a large market for hydro in the country. Even without the 250 MW FIT requirement for mini-hydro, larger hydro projects are profitable. Based on the research there seems to be little issue with displacement of local inhabitants. With the clear focus on renewable energy, the market for hydro should be upbeat as hydro is one of its cheaper sources.

1.2.2.7 F6 MOBILIZATION OF RESOURCES
There is no lack of financial resource, nor in locations that support the conditions for hydro and mini-hydro, in the country.

1.2.2.8 F7 ADVOCACY COALITIONS
With all the hydro power projects being approved it doesn't appear that the hydro power companies lack support from the government.

1.2.3 VIRTUOUS AND VICIOUS CYCLES
1.2.3.2 VIRTUOUS CYCLE
The initial attempt by the government to push mini-hydro did not appear to have much traction (F4). But with the FIT and possibly better technology this time around the response of the industry players is more enthusiastic (F4) (F1) (F5). In fact the momentum that started the RE Act of 2008 was probably sufficient to push the
players to embark on larger hydro power projects (F4) (F6).

1.2.3.3 VICIOUS CYCLE
However the lack in government follow-through and probably the weak incentives (F4) weakened the government's initiative to develop the local hydro turbine manufacturing industry, eventually causing it to fail.
Secondly, indiscriminate approval of large-scale hydro projects might cause backlash from poor upland settlers who will be displaced by it. If the government is not judicious in approving the applications and in ensuring that those displaced are sufficiently relocated and compensated it might cause bad publicity and halt the momentum in building hydro power plants, apart from unjustly dispossessing the settlers.

1.3 WIND TURBINE TECHNOLOGY
1.3.1 BACKGROUND OF WIND POWER AND WIND TURBINES IN THE PHILIPPINES
The first on-grid wind farm in the Philippines was the Bangui wind farm (33 MW), commissioned in 2005. Only much later, in 2014, were new wind farms commissioned, led by the Burgos wind farm (150 MW) and Caparispisan (81 MW). More wind projects have been approved for 2015, many of them qualifying for the FIT program. The industry players are led by the Lopez group's EDC.

F1 ENTREPRENEURIAL ACTIVITIES
Since 2014 there have been a lot of wind energy projects, most likely owing to the government's FIT scheme. The three wind farms covered by FIT are: Burgos wind farm (150 MW), Caparispisan (81 MW) and Bangui phase 3 (18.9 MW).

THIS RESEARCHER WAS NOT ABLE TO FIND ANY LOCAL WIND TURBINE MANUFACTURER.
1.3.2 SYSTEM FUNCTIONS
1.3.2.2 F2 KNOWLEDGE DEVELOPMENT
Compared with hydro turbines there is more research on wind turbines, 28. This number is still low compared with those of our neighbors: Indonesia (67) and Malaysia (227). Given the monopoly in wind turbine production, it is unclear how the country can benefit from these researches. One possibility is in the development of small-scale wind turbines which are actually left out in the FIT scheme projects.
The installation of the wind farms is done as a joint-venture with foreign companies. It is still unclear whether any of the local players have plans of installing wind farms on their own and of learning this technology.

1.3.2.3 F3 KNOWLEDGE DIFFUSION
Some of the research done on wind turbines is in collaboration with foreign universities. Apart from this there are no known local initiatives to transfer wind turbine development or manufacturing technology locally.
1.3.2.4 F4 GUIDANCE OF THE SEARCH
There is great momentum in building wind farms in the country, spurred by the FIT scheme. Additionally the DOE released an updated Wind Resource (atlas) in 2015 with the hopes of spurring more investors to the local wind energy sector. Unlike hydro turbines, there has been no attempt to develop local wind turbine manufacturing. It is probably because unlike hydro, the wind projects covered by the government incentives are all large-scale projects. In some cases the wind turbine manufacturers themselves installed the turbines which Vestas did for the Burgos wind farm.

1.3.2.5 F5 MARKET FORMATION
The initial FIT requirement for wind was 200 MW at P8.53/kWh. This has been expanded by another 200 MW at P8.49/kWh for projects in 2015 to 2016. It is clear that the FIT scheme is working in its aim to make wind energy projects feasible. There is no indication that the increase in wind energy requirements will lead to the creation of a local wind turbine industry. If the local hydro turbine manufacturing industry, which has a much larger local market, is underdeveloped, there is less hope for the development of a local wind turbine manufacturing industry.

1.3.2.6 F6 MOBILIZATION OF RESOURCES
The government has updated the country's wind resource atlas in hopes of attracting more investors. Already its initial FIT's wind resource atlas have been met. With both the FIT scheme and the wind resource atlas, investors will most likely not be lacking in the wind energy sector.

1.3.2.7 F7 ADVOCACY COALITIONS
As with other FIT supported energy sources, the government is open to increasing future FIT requirements if its current requirements are met.

1.3.3 VIRTUOUS AND VICEIOUS CYCLES
1.3.3.2 VIRTUOUS CYCLE
As with other FIT supported renewable energy resources (F4) (F5), wind energy projects have been increasing since 2014 (F1). This is foreseen to continue as long as the government approves additional FIT requirements in the coming years. The projected wind capacity targets, unlike the other renewable energy sources, have actually been downgraded. Its target in 2011 was an additional installation capacity of 1048 MW by 2015 but as of this writing the added installed on-grid capacity is only 231 MW. The government might have been too optimistic in its feasibility projections for wind energy and the interest of the local players. It is possible that the commissioned new wind atlas was to help increase demand from the industry. Based on number of wind projects for DOE approval as of writing, the appetite for them has surely bounced back. Depending on the continued interest in wind projects it might be economically beneficial if the government (F4) incentivizes local manufacture of wind turbines.
1.3.3.3 VICIOUS CYCLE
As with solar the cost of setting up wind farms is still not feasible without the FIT. As with solar it is unclear up to how much the government will increase the FIT requirement for wind (F4) (F5). As the wind FIT rate is double the current market rate of electricity, any significant increase in its requirement will significantly increase the electricity rate. If this happens this might cause a severe effect on wind farm installation (F4).

1.4 BIOMASS TECHNOLOGY
1.4.1 BACKGROUND ON BIOMASS
Biomass actually covers several technologies that convert organic substances to energy. Biomass energy is produced through: combustion, anaerobic digestion, gasification, and chemical or biochemical conversion. It covers using waste to harness energy as well as adding substances derived from plants and the like to fuel. Biomass is available from three major crops, rice, coconut and sugar. Its attractiveness is that it uses the wastes of these crops as fuel. In 2012 the 10% ethanol mandate for gasoline was implemented. It was supposed to be increased to 20% by 2020. But the country can only produce 17% of its current ethanol needs so increasing ethanol requirement to 20% seems to be challenging. Secondly, a European Union study showed that the carbon emission reduction from biofuels is offset by the emission of greenhouse gases in the production of ethanol which is also problematic.

1.4.2 SYSTEM FUNCTIONS
1.4.2.2 F1 ENTREPRENEURIAL ACTIVITIES
As of March 2015, 14 biomass projects have been approved by the DOE, with a total capacity of 99.68 MW. These are led by Universal Robina Corporation (31 MW) and Isabela Biomass Energy Corporation (18 MW). Aside from sugar cane bagasse and rice hulls, the approved projects include methane extraction from land-fills: Montalban (2.175 MW) and Payatas (0.876 MW).

1.4.2.3 F2 KNOWLEDGE DEVELOPMENT
Since the covered technology of biomass is broad, it is hard to find a keyword specific or general enough to cover the correct technologies. In the interest of time, this researcher used the keyword “biomass” in conjunction with “energy” or “power”. Based on this there is a significant number of research in biomass, 48, compared with the previously discussed renewable energy resources. Part of the reason could be the wide scope covered by this technology and its broad applicability. But we still lag behind our neighbors in biomass researches--Indonesia (124), Malaysia (592). Still the recent increase in local research is encouraging.
For the installation of more advanced biomass power plants the local companies are still highly dependent on foreign technology. These are either turn-key projects or joint-ventures with the foreign partner. Although the government has included RND on biomass technologies and biofuels as part of the NREP, there has been no report on the progress on this. It is unclear what research the government will support.

1.4.2.4 F3 KNOWLEDGE DIFFUSION
There are some research collaborations with foreign universities but most of the researches are done by local universities. For building of the more advanced biomass power plants, like cogeneration, the local companies made a joint-venture with foreign companies that had the expertise. It is unclear if the local companies intend to gain the technology themselves or simply wish to help in building these advanced biomass power plants.

1.4.2.5 F4 GUIDANCE OF THE SEARCH
The interest in biomass is high. Many more companies are signaling their intention to build biomass power plants.

1.4.2.6 F5 MARKET FORMATION
Unlike solar and wind, the initial FIT requirement for biomass, at 250 MW for P6.63/kWh is still not reached. This is expected though as unlike the two, the fuel for biomass power plants is limited. However, the interest on the part of new players indicates there is still a market for biomass power.

1.4.2.7 F6 MOBILIZATION OF RESOURCES
At the moment the biomass projects use feedstock from rice and sugarcane. The

‡ www.scopus.com
researcher was not able to gather what feedstock the planned biomass projects will be using. Coconut husks and fronds are another source of feedstock, although it is not certain whether local production is sufficient for a biomass power plant.

1.4.2.8 F7 ADVOCACY COALITIONS
There doesn't seem to be as much lobbying activity from the biomass players. It might be because the projected FIT requirement is in-line with the amount of available biomass fuel resource.

1.4.3 VIRTUOUS AND VICIOUS CYCLES
1.4.3.2 VIRTUOUS CYCLES
Since 2008 the building of biomass power plants has been constant (F1). Most probably companies will be building biomass power plants to make use of their wastes even without the FIT scheme (F5). However, with new players being added, it is most likely that the FIT scheme is making it more attractive for more companies to join the sector (F4). For some biomass and other renewable sources might be a stepping stone to bigger energy projects like oil (F5). Even with a finite source of feed stock (F6) the requests for FIT approval are still increasing. It is likely because of this that the number of biomass projects might eventually decrease.

1.4.3.3 VICIOUS CYCLES
The biofuels gained their peak in 2012 with the E10 regulation. However, since then the country has struggled to supply the nationwide ethanol requirement to fill this. The local market can only produce 17% of the total ethanol requirement in the country. Because of this and on account of international studies that showed minimal greenhouse gas reduction from biofuels it is unlikely that the government will implement its E20 requirement on 2020.

2 CONCLUSION AND RECOMMENDATIONS
For solar and wind power the strongest system functions are the entrepreneurial activities of old and new players (F1) and the influence on the government they wield in increasing the FIT requirement (F7).
For photovoltaic cells there is no government initiative to encourage local manufacturing capability, neither are government and industry players interested in developing photovoltaic cell development capability. It seems the focus is just on installing more photovoltaic cells and no thought is given to participating in the photovoltaic cell chain as either manufacturer or developer. As it is the government and local companies are just users of the technology without input in the direction of the technology. It is just assumed that photovoltaic cells will continue to be cheaper and cheaper and become more efficient. But without any input in the technology the country becomes a passive user without any capability to drive its development.
It is the opinion of the researcher that with the presence of cheaper fossil-fuel based energy, it is not the primary responsibility of the country to drive down carbon
emissions. Its primary responsibility is the economic welfare of its people. Increasing the FIT requirement for solar panels will just drive up electricity rates for the Filipino people with nothing to show for it. It is the recommendation of this researcher that a local content requirement mechanism be enforced on the next batch of FIT applicants, that a higher FIT rate can be applied to solar plants that meet the local requirement in photovoltaic cells. Secondly, another set of incentives for solar plants that meet local design requirement might be in the form of another batch of FIT requirements. For mini-hydro this same scheme can be applied. A higher FIT rate can be awarded to producers that use locally manufactured turbines and generators. A second batch of incentives can be provided, such as another FIT rate, for components that are designed locally. In the case of wind power the anticipated demand for projects (F5) is still smaller than the actual quota although it is slowly increasing. Given that the scale of equipment used in wind farms is much larger than that in mini-hydro, developing manufacturing capability will be harder. In this case, as the FIT requirement is not yet filled, the government has time to monitor and study the incentives used for solar and mini-hydro, in formulating the incentives it will offer for encouraging wind power technologies such as wind turbines. If the incentives for hydro turbines gain traction, a local hydro turbine manufacturing industry should have been developed, in say five years. This can be a starting point for the development of a wind turbine industry by using FIT or other incentives for local content and design. But for local content to be available, the government should first encourage the establishment of local manufacturing for photovoltaic cells and hydro turbines. For photovoltaic cells, a foreign owned local manufacturer already exists. So offering incentives for local requirement will not be as difficult. However incentives for other manufacturers to set-up shop locally should also be provided. Incentives in terms of income taxes, VAT and equipment importation should be offered to attract more manufacturers. However, as with the FIT requirement, these incentives should be given based on a production limit, for instance, a manufacturing output based on power capacity of the photovoltaic cells. Say the new FIT requirement is for additional 1500 MW solar capacity. The incentives for photovoltaic cell manufacturing will be based on a capacity of roughly 1500 MWs of photovoltaic cell capacity production per month or year, given for a 10-20 year period. Interested parties will bid on this manufacturing capacity. Only their approved output capacity is covered by the income tax and VAT free incentives. This energy capacity based production incentive is also applicable for hydro and wind turbines. In this manner the Philippine market will not be needlessly saddled by higher electricity prices. With it will come more employment and more high-value industries; and with more economic activity the greater the energy requirements that can be filled by cheaper sources, fossil-fuel or renewable. And with deeper involvement in the photovoltaic and turbine technology, the local industry can help drive down prices even more. The incentives for encouraging biomass technology development will be a bit different. First, this researcher has not come upon data indicating that demand for new
biomass projects will be sustained years from now. So incentivizing equipment manufacturing for large-scale biomass projects might not be feasible. Developing technology for smaller-scale off grid biomass combustion might be more attractive. Secondly, a feasibility study on developing modularized cogeneration modules for biomass burners or fossil-fuel based ones might be useful and necessary.

3 BIBLIOGRAPHY

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