Assessing the Impacts of Solar Electrification Program in Rural Schools: Experiences from the Field

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Electricity drives development. It increases productivity, enables efficiency, and generally improves the overall quality of life. Its impact in various sectors cannot be overemphasized, particularly in the education sector. This article highlights the experiences of nine rural public schools in the Philippines as beneficiaries of a solar electrification program. It analyzes the impacts of access to electricity by looking at how the experience of the students changed, the innovations introduced in teaching, and the modifications made to administrative operations. The findings highlight that the more direct impact of electrification is the provision of a better environment for learning. It also highlights other positive externalities as well as unintended consequences of having access to electricity. The article argues that although electrification has helped expand the opportunities for other stakeholders to get involved in improving education in rural areas, social buy-in needs to be continually secured and reinforced as well as strategic collaboration to be established to leverage the limited resources of the schools together with the willingness of the community to provide additional support towards sustaining the program.

***Keywords*:** *solar electrification, rural public schools, impacts, education*

Access to electricity is life-changing. The benefits that can be derived are numerous. Aguirre (2017) divides the benefits of electrification into two: direct and indirect. Direct benefits include better lighting and the use of electrical appliances such as television, radio, and refrigerator, etc. Indirect benefits include better educational outcomes, improved productivity, income generation opportunities, and other benefits that may be indirectly acquired from using electricity (Aguirre, 2017). Studies conducted by the World Bank Independent Evaluation Group (IEG) (2008) and the United Nations Department of Economic and Social Affairs (UN DESA) (2014) highlighted the roles of school electrification in having better equipment and facilities for teaching, extending teaching, and studying hours, and enhancing other social and economic developments such as health and sanitation.

In the education sector, electrification remains one of the drivers of development challenges in terms of providing access to electricity in rural schools. Despite progress in electrifying rural areas and connecting nearly two billion people to national electricity networks, efforts to electrify schools have lagged (Sovacool & Ryan, 2016). In the Philippines, based on the submission of the Department of Education (DepEd) to the Senate Committee on Energy on 23 September 2019, there are 1,664 public primary and secondary schools without access to electricity, affecting 380,529 enrolled students (Senate Resolution 330, 2020).

An earlier study by the Energy Sector Management Assistance Program (ESMAP) (2002) in the Philippines revealed that children in electrified households have higher education levels than those without electricity with an almost two-year difference, 8.5 versus 6.7 years. This is further supported by the recent study on the performance of energized and non-energized schools in the National Achievement Test (NAT). On the average, energized schools performed better in the NAT than those that did not have access to electricity (12% better for elementary schools and 10% better for secondary schools) (Capule-Navarro & Alampay, 2020).

Literature on the impact of rural electrification on development has been growing (Khandker, Barnes, Samad, & Huu Minh, 2009). However, benefits attributed to rural electrification programs rest largely undocumented for lack of impact evaluations (Bernard, 2010, p. 42). This study aims to contribute to address this gap, especially in rural public schools in the Philippine setting. It focuses on the school beneficiaries of One Meralco Foundation's (OMF) School Electrification Program (SEP).

The OMF is the social development arm of the Manila Electric Company (MERALCO) that focuses on "advocacies that bring about productivity to households, schools, and communities through electrification" (OMF, 2019, p. 1). The SEP seeks to provide public schools in far-flung *barrios* and remote islands with a sustainable power source by harnessing solar energy. Since its launch in 2011, the program has already energized 245 off-grid island and mountain public schools in 38 provinces (OMF, 2019). These schools had never been energized because they were remote that connecting to the power grid would be a tough challenge. In implementing the program, OMF collaborates with the DepEd and local communities (e.g., local government units [LGUs], parent-teacher association [PTA], etc.).

This article is divided into five sections. The next section presents a literature review on the effects of electrification in rural areas and particularly in schools and on learning and education. The discussion focuses further on the use of renewable energy as an option for an off-grid source of electricity. The

third section explains the methodology used in conducting the study. The results were assessed and analyzed in the fourth section, while the last section provides the conclusion and recommended actions toward sustaining the gains of school electrification.

Impacts of Rural and School Electrification

Electricity is a development tool. Access to electricity can improve socio-economic conditions in developing countries, particularly in the areas of income, productivity, education, and overall quality of life (Mejdalani, Mendes e Costa, Hallack, Lopez, & Vazquez, 2018; Sovacool & Ryan, 2016; Kanagawa & Nakata, 2008 as cited in Torero, 2015).

Rural electrification leads to several benefits. Torero (2015, p.7) summarized the documented benefits of rural electrification cited in the IEG (2008) study as follows:

- Income benefits from access to electricity through new work opportunities, especially in nonfarm activities
- Leisure and domestic benefits from lighting and TV/radio
- Time savings from household chores can be used for leisure and productive activities
- Education benefits through higher earnings for children living in electrified households that have higher educational attainment
- Increased productivity of home business through higher revenues of existing businesses and the creation of new home business
- Increased agricultural productivity through higher revenues
- Improved health outcomes and reduced mortality through improved indoor air quality from changes in lighting sources
- Reduced fertility at lower costs, is achieved through information channels that use electricity instead of reproductive health programs
- Public goods benefits, such as increased security and lower environmental contamination.

With these benefits, areas with electricity are likely to be more developed than those without access to it. As such, rural electrification has always been a development strategy. It has been claimed to have substantial benefits, promoting production and better health and education for households (Torero, 2015). Integrating rural electrification program with complementary services is crucial for its success (Peters, Harsdorff, & Ziegler, 2009).

Electricity at home can lead to better lighting which in return provides the opportunity for adults to engage in productive activities such as handicrafts, or be able to keep a home business open for extended hours in the evening. The use of electronic devices (e.g., radios, televisions, and computers) provides information, knowledge, leisure, and entertainment (Samad & Portale, 2018).

The effects of electricity on learning are directly related to the availability of artificial lighting (Mejdalani et al., 2018). Improved lighting provides an opportunity for children to spend more time on their studies. The increase in children's study hours will likely improve their school attendance, as is their grade completion level (Samad & Portale, 2018). Extending possible teaching and studying hours through artificial lighting is particularly important in rural areas where students usually work on family farms during the daytime (Mejdalani et al., 2018).

Electricity also provides access to information that can lead to non-formal education. Chances of knowledge building up about health and hygiene, especially among women, increase with access to electricity (Olanrele, Lawal, Dahunsi, Babajide, & Iseolorunkanmi, 2020).

In Brazil, the study on the program by Mejdalani et al. revealed that:

> …electrification programs have a significant effect on the dropout rate of rural schools…. Also, it provides hard evidence that proper infrastructure for teaching and learning during the initial years of schooling plays an important role in retaining children at school and thus potentially reduces child labor. Moreover, the gains that programs like the Light for All in Schools have made in rural areas help reduce inequality, first by reducing the educational gap between areas with different urbanization levels and, second by providing higher human capital to less-developed regions. (2018, p.7)

School electrification creates opportunities for the stakeholders to work towards a better learning environment and improved school operation. Sovacool and Ryan (2016, p. 111) identified five benefits of electrifying schools: (1) lighting and extended studying hours, (2) facilitation of information and communication technology (ICT) in the classroom, (3) enhanced staff retention and teacher training, (4) better school performance through attendance, completion rates, test scores, etc., and (5) co-benefits such as improved sanitation and health,

gender empowerment, and community resilience. Access to electricity improves administrative processes in the school, as well as the educational services it offers (Lenz, Munyehirwe, Peters & Sievert, 2017). Electricity enables schools to use mass media to supplement normal classroom instruction. Efficiency in processing information, particularly examinations, has improved with the aid of computers and photocopying. It also enables teachers to provide extra teaching in early mornings and late evenings to make up for material not adequately covered during normal teaching hours due to a lack of teachers (Kirubi, Jacobson, Kammen, & Mills, 2008).

Access to electricity also produces multiplier effects, such as gender empowerment, strengthened disaster resilience, and improved health and sanitation. A study on the impact of electrification on access to education in the Wayuu indigenous communities of Venezuela revealed that while both genders have had similar opportunities due to electricity, women have taken greater advantage by studying at night, reducing their domestic workload and accessing information, reinforcing their position as a community and domestic leaders (Lopez-Gonzalez, Domenech, & Ferrer-Marti, 2020, p.7). Another study in Northwestern Madagascar also showed that access to electricity allows girls, who need to do more household chores than boys, to do their homework in the evening (Daka & Ballet, 2011). Electrification efforts can also help to solve some of the problems in health care (e.g., vaccine refrigeration), water, and sanitation (e.g., toilets with running water) (Welland, 2017). Electricity can facilitate the use of emergency radios or disaster warning alarms (UNDESA, 2014). With the increase in levels of education due to electrification, communities also become more resilient during natural disasters (Robinson & Winthrop, 2016 as cited in Welland, 2017).

Renewable Energy as an Option for Electrification

Off-grid renewable energies play a key role in electrifying rural schools. Solar energy, as one of the options for off-grid renewable energies, can help level the access gap, particularly for remote rural areas that are unlikely to receive grid electrification (Welland, 2017). Brooks and Urmee (2014) mentioned that solar energy is often preferred as the enabling technology for many off-grid electrification projects due to its versatility, extremely low operating costs, and environmental sustainability. Photovoltaics (PV) proves to be a highly effective means of meeting essential needs such as lighting for homes, schools, and community centers (Brooks & Urmee, 2014). Torero (2015) highlights the importance of studying off-grid solutions and exploring what kind of sources are most effective for a given setting.

Utilizing renewable energy has its challenges. Foremost among these challenges is maintenance. According to Brooks and Urmee (2014), the main reason for failure in most PV projects is the non-inclusion of maintenance and service as part of project development, which results in short-lived electricity supply and users' mistrust (Pueyo, Spratt, & DeMartino, 2014). Related to this challenge is the lack of training, which becomes noticeable when systems fail or there is a drastic reduction in lifespan due to user error, abuse, or poor installation (Brooks & Urmee, 2014). The training is important for end-users since the remoteness of the site for off-grid electrification leaves them ultimately responsible for all ongoing maintenance and operation of the system (Brooks & Urmee, 2014). The use of renewable energy sources also creates some technical difficulties like intermittent supply, which can potentially compound affordability concerns (Pueyo et al., 2014).

Several studies offered some solutions to address these challenges. Brooks and Urmee (2014) propose adequate training in system operation and basic maintenance as well as the need to have a standardized renewable energy training curriculum. The study of Pueyo, et al. (2014) recommend situating the generating capacity of off-grid energy in the right places to make the supply more accessible and affordable. Collaboration among the stakeholders is also important in addressing the earlier mentioned challenges. Community involvement through village organizations is crucial to leverage local resources and promote increased access to off-grid rural electrification (Kirubi et al., 2008). In implementing solar projects, Sinha and Sethi (2015) mention that collaborations between a government and a private organization promise both innovation and efficiency. Private participation should be encouraged, through transparent and simple procedures, in promoting renewable energy efforts (Olanrele et al., 2020). The UNDESA (2014) study underscored collaborations involving governments and key stakeholders (e.g., businesses, nonprofit organizations, banks, etc.) as one way to raise needed investment to achieve electrification. As such, costs concerns can potentially be addressed by accessing the climate finance that renewable energy offers (Pueyo et al., 2014).

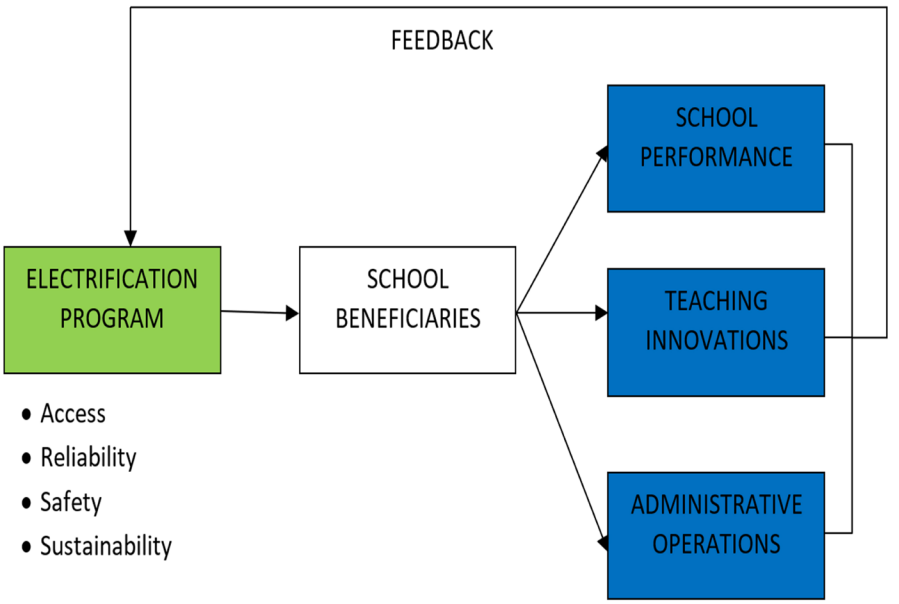
Methodology

The research was conducted using a basic input-output model (see Figure 1). It was based on the assumption that electrification of OMF's beneficiary schools will improve the learning environment and lead to mainly positive changes in the overall performance of both teachers and students.

As such, the evaluation considered the electrification program as a new input among beneficiary schools, and the change thereafter is manifested in terms of its expected effects on school performance, teaching, and administrative operation.

Through the electrification program, schools gain access to reliable electric service and safety in terms of service provision, and long-term sustainability.

Figure 1
Evaluation Framework



Source: Formulated by the Authors

Inquiries among stakeholders pertained to questions related to outcomes comparing the context of pre- and post-implementation of the electrification program. Efforts were exerted to collect data on quantifiable changes or effects in the schools' performance (e.g., scores in national achievement tests, participation, and performance in competitions) but the schools were not able to provide comparable data across the requested years. The qualitative impact of the program on school heads, teachers, students, and parents was investigated. Through a series of key informant interviews (KIIs) and focus group discussions (FGDs), questions were asked on how the SEP has impacted lesson preparation and coverage, learning activities, teaching style, school operation, and costs, among others. Lastly, other positive externalities were also assessed to gain insights on the added benefits of the program in the school and the community. The qualitative data were then transcribed, processed, and analyzed by thematic areas as presented in Figure 1 (i.e., school performance, teaching innovations, and administrative operations).

The selection of school beneficiaries was done in consultation with OMF being the program owner. It was agreed that there should be representation from Luzon,

Visayas, and Mindanao. The availability of the respondents during the scheduled field interviews (April-May 2016) and the year of program implementation were also considered in the selection process. A total of 140 respondents from nine schools participated in the FGDs and KIIs. The respondents were composed of eight school heads, 47 teachers, 48 students, and 37 parents (see Table 1).

Table 1
Breakdown of Respondents

School	Province	Year of SEP implementation	School Head	Teachers	Students	Parents	Total
Lubol Integrated School	South Cotabato	2014	1	8	7	11	27
Kibang National High School	South Cotabato	2014	1	4	5	2	12
Parang Cueva Elementary School	Batangas	2011	1	7	3	3	14
San Agustin Kanluran ES	Batangas	2012	1	4	5	4	14
Cayabu Elementary School	Rizal	2013	1	4	2	4	11
Cayabu High School	Rizal	2013	1	3	6	3	12
Tinucan Elementary School	Rizal	2013	1	6	6	3	16
Doong National High School	Cebu	2013	1	3	11	3	18
Limasawa National High School	Southern Leyte	2013	1	8	3	4	16
Total			8	47	48	37	140

Results and Analysis

Teaching and Learning Innovations

> *Nakakatulong sa mga bata yung pag* hands-on *sa* computer. *Hindi talaga nakakatulong sa bata kung* picture *lang papakita mo.* For example *bili lang kami ng* picture *ng* keyboard *ng* computer *tapos papakita lang namin, hindi yun* effective *sa bata. Mas maganda at natututo talaga sila pag yung nahahawakan nila at nasusubukan ang* computer. (It would not help the students if you will just show them a picture. For example, if we are just going to buy a picture of a keyboard and will just show it to them, it is not effective. They can learn more if they can feel and actually use a computer.)
>
> -Teacher from Lubol Integrated School, South Cotabato

One of the apparent qualitative impacts that was reiterated in all the schools that were visited was how electrification leds to innovative changes in how many subjects were taught. However, many of the innovations were due not directly to electrification per se, but to the additional equipment and materials that electrification enabled teachers and students to use. Foremost among these were televisions, microphones, computers, projectors, speakers, and printers, among others. These hardware were then useful in transmitting new content, materials and multimedia, which was also enabled by growing internet access in the community.

Obtaining these equipment and hardware was not programmed into the design of the program and has administrative implications for the school in terms of getting funding support to obtain or purchase them. Obtaining these equipment also allowed schools to offer subjects/topics they could not teach before. For instance, before electrification, computer classes could not be taught because the schools had no computers. A summary of some of the teaching innovations is listed in Table 2.

A common example given pertained to teachers being able to provide more interesting and diverse examples and materials. In music, some teachers gave the example of providing videos of dances and audio of music. In English class, some have shown videos of '*Romeo and Juliet*.'

In science, one teacher mentioned showing videos of the digestive system at work, or demonstrations of some experiments. A teacher gave one example:

> *Sa Science, pagkatapos ng* lecture *ay may panonoorin ang mga bata. Mas natatandaan na ang mga itinuturo. Kapag manonood, halimbawa ng MathTinik, itinuturo ko muna tapos panonoorin ng* students. (In Science, after a lecture, the kids are given something to view. This makes it easier to them to remember what was taught. If one watches, example MathTinik, I teach first before the students watch.)

What this shows is that a teacher does not make the technology a crutch, but, rather, they make it complementary to the lessons they need to impart. In so doing, they say students are more engaged.

> *Naboboring sila, inaantok sila (in the past), pero kung gagamitan mo sila ng* TV *na mapapanood ang kinukuwento mo ano parang* attentive *sila.* (In the past) they get bored, get sleepy, but if you use TV where they can watch the stories, they become more attentive.)

Table 2
Teaching Before and After Electrification

Before	After
Audio	
• Difficult to teach music because they could not hear the actual songs/music	• Students can listen to the actual music from different cultures/places with the aid of laptop
Visual	
• Unable to watch anything without electricity	• Use of smart TV in Speech class to demonstrate proper pronunciation
	• Listening to the actual songs of Arirang
	• Recorded presentations of Noli Me Tangere and Florante at Laura
• Pictures and illustrations are mainly black and white.	• Can use TV for Grade 1 – media downloaded from the internet are shown on TV
	• Use of content from CDs for Araling Panlipunan which are more attractive
Reproduction of Materials	
• Had to travel a long distance to print and had to depend on other people to do this because they did not have a laptop	• Some schools now have photocopiers and give individual copies to each student
	• Teachers can now easily revise and replicate their lessons with laptops and printers.
• Chalk-talk; Pictures are only shown from a book (e.g. Da Vinci's picture and paintings) Use of "MP4" (several pieces of Manila Papers [MP]) to reproduce lessons from books.	
Interactivity	
• No hands-on teaching of computers	• Computer classes can now be taught in EPP
	• Some activities can be added and followed on social media (e.g., Facebook)
	• More interactive: game apps can now be downloaded using the TV /cellphone that students can play (ex. games involving spaceships to demonstrate lesson for multiplication)

Learning Materials Used	
• Only a few had laptops	• In some schools, everyone now has a laptop and everyone can really use it. • Use of PowerPoint
• Used manila paper, cartolina, and cut-outs for presenting lessons	

This was validated by one student who said: "*Mas gusto ko po ngayon kasi mas malinaw na ang mga* pictures. *Mas naiintindihan iyong mga* videos. (I like it better now because the pictures are clearer. I can understand the videos better.)"

As such, new materials being introduced can be more interesting, clearer, and better understood by the students.

In addition, electrification, by allowing access to videos and other digital materials, enable them to show things they would not normally be able to physically show during ordinary class periods. For instance, a Science teacher shared: "...*yung* constellations, *hindi ko naman puwede ituro sa kanila (dahil) pag gabi (lang ito)*. (You cannot ordinarily teach about constellations since you could only see these at night.)"

Electrification has also helped the teachers and the students to prepare better for academic competitions. Teachers were able to extend review sessions, while the availability of TV, computer, and internet exposed the children and teachers to information that were not readily available before. These experiences are consistent with the identified benefits of school electrification of having an extended studying hours due to availability of artificial lighting and facilitation of ICT in the class as identified by Sovacool and Ryan (2016) and Mejdalani, et al. (2018).

Many of the head teachers and school heads believe that teaching innovations resulting from electrification have encouraged students to study more and learn better. For example:

> *Yung mga* topics *na kailangan ng* video*, mas makakarelate na yung mga estudyante kasi nakikita na nila. Napakadali na ring mag*-replicate *ng mga* reviewers. (Students can now relate easily to topics that require a video since they can watch them. It is also easier to replicate reviewers nowadays

In other words, many of the innovations pertain to the content they are able to access online, and sharing this with the students would not have been possible without electricity.

Students also became more creative and innovative in their schoolwork and assignments. In Limasawa, for instance, some students not only research and search for video materials, but they also prepared and made 'movie trailers' for their Filipino subject. Many students reported preparing PowerPoint. These are very useful skills for the digital economy. There were also reported practical benefits, such as children being more comfortable with the use of microphones for public speaking.

Because of this, some students also felt more empowered. As one student said:

> *Ngayon, kami na rin nagsasalita sa harap kung may pinagagawang kailangan naming i-*explain *kasi nagbibigay naman ng mga* pictures *naka* print *sa papel o kaya pinanood namin sa* laptop. (These days, we are the ones who speak in front if there are things that need explaining because there are now printed pictures or those we can watch on the laptop computer.)

The identified benefits for the students (e.g., being more creative and innovative and building self-confidence) go beyond the direct intended effect of school electrification by improving the learning environment and highlight its effect on capacitating and empowering the students. These complement the findings on the effects of school electrification by empowering the students on areas of knowledge building on health, hygiene, and sanitation (Olanrele et al., 2020; Welland, 2007) and gender and disaster resilience (Lopez-Gonzalez et al., 2020).

The program seems to have little impact on why students discontinue going to school. Most of the reasons cited by the teachers, students, and parents alike were social/personal in nature (e.g., need to help parents eke out a living, teenage pregnancy, peer pressure, distance of student's house to school, etc.). Nevertheless, there are cases when electrification has been instrumental in helping students keep up with class requirements. For example, a student reported that:

> *Puwede nang mag-*review *sa* school *kahit hanggang* 6 pm*, bago umuwi. Wala kasing kuryente sa bahay.* (It is easier to read now with the lights. I can review in school even until 6 pm, before going home. We don't have electricity at home.)

Changes in Administrative Operations

Improved day-to-day operations. The electrification program also effected changes in the administrative operations of the school. For one, it allowed teachers to stay in school beyond school hours if and when necessary. Unlike before when teachers were forced to leave by sundown, they can now stay longer to prepare lesson plans and other school-related activities. This arrangement is particularly helpful during reviews and in preparation for various academic competitions.

Solar electrification also ensured class continuity in some areas even when it gets dark because of rain. In Tinucan, one student leader reported that: "*Ngayon, may ilaw na. Nakakapagklase pa rin kahit umuulan*. (Now, we have lights. So classes can go on even when it rains.)"

Records management has likewise changed for the better. As noted by one teacher: "Permanent record *namin hindi na* hand-written, *may* soft copy *na*. (Our permanent records are no longer handwritten; we now have soft copies.)"

This is particularly important in the storage, retrieval, and overall maintenance of school records. Back-up copies can now be easily produced as part of contingencies in cases of disasters and other catastrophes.

The preparation of reports is now easier as well. Before, some schools depended on diesel-powered generators, which they had to turn on first even just to print a one-page document. The situation is even more cumbersome in Doong National High School where they can only use electricity from a generator provided by a local cooperative after school hours, that is, from 5p.m. to 1a.m. In other cases, students had to go to neighboring communities in order to print school requirements. This has changed with the introduction of solar electrification. In the words of the school head from Parang Cueva:

> *Napadali na ang pagplano [ng mga]* activities*… Madali nang makapag-*research through internet*. Madaling magprint ng* reports*.* (It has made planning for activities easier. It is now easier to do research through the Internet. It is easier to print reports.)

The electrification program opened up other opportunities for the schools. Some reported that it is now easier to ask for donations as donors are encouraged by the available electricity. This is consistent with studies that show people are willing to pay for electricity due to perceptions of its good benefits (Energy Sector Management Assistance Programme [ESMAP], 2002). These include municipal and provincial governments, private individuals, parents, and alumni who have donated different equipment from monitors, ovens, fans, projectors, laptop, printers, TV, inverter, and battery to a reading room. As observed by a parent from Parang Cueva: "*Madali na makahanap ng* sponsor *kung may* power *na*. (It is easier to get sponsors nowadays since we have electricity.)"

This change is also attributable to the fact that it is now easier for them to prepare request letters. This is particularly important for far-flung schools like Kibang National High School, which do not get visited by higher officials too often. In the words of its school head:

> *Minsan lang po bumibisita [ang mga* officials*] so kapag nasa* school *po sila agad-agad kami gumagawa ng* request letter *at agad din namin naibibigay at nalalalaman din naman namin ang* response *nila*. (The officials seldom visit us, so when they are here, we immediately prepare request letters, print them, and right there and then, we get their response.)

The school electrification provides key stakeholders the opportunity to establish strategic collaboration. Their experiences can be considered as vital components for building strategic collaboration where it "produces positive impacts, stakeholders committed to policy or program change, and strengthened the capacity of individuals and organizations to effectively work together" (Norris-Tirrell & Clay, 2010 as cited in O'Donnell, 2012, p. 2).

Enhanced functionality of facilities. The availability of electricity has enhanced the functionality of existing facilities, especially the library, canteen, and Home Economics (HE) rooms. Some schools now have an audiovisual room or an ICT area inside the library. This complements the addition of new equipment such as electric fan, photocopier, computer/laptop, and printer. For teachers and parents, these changes encourage students to use the library more often. This was confirmed by one student leader:

> *Noon ay pumupunta lang sa* library *para hihiram at babasahin sa labas para makita. Noong may kuryente na, sa loob na magbabasa. Mas madalas na akong pumupunta sa* library. (Before, we only went to the library to borrow books, then read them outside. Now, we read the books inside. I visit the library more often these days.)

The increase in library visitors was corroborated by one teacher: "*Mas marami po ngayon* (*gumagamit ng* library), *lalo na kasi po may* TV *po dun sa* library. (We now have more library users, especially since we've had a TV.)"

Aside from reading and studying, there were also reports of students doing their projects in the library where there is ample light and ventilation.

The HE rooms likewise became more functional with the availability of electricity. In Cayabu and Tinucan, electric equipment for cooking, heating, and other uses are now possible to use.

Another facility that has improved is the canteen. With electricity, canteens in some schools can now be operational most of the day, regardless of weather conditions. In Tinucan, students reported that:

> *Noon, madilim kapag tag-ulan. Mas maganda na ang* canteen *ngayon, nagagamit namin maski umuulan. Wala pang* ref *pero may ilaw na.* (Before, it gets dark when it rains. Now, it is better and we can use it even when it is raining. We don't have a refrigerator yet, but there is light).

The use of HE rooms and canteens is crucial especially in implementing the school feeding program to address undernutrition among Kindergarten to Grade 6 pupils.

Furthermore, electrification paved the way for some rooms to have multiple uses. In Tinucan, the school head's electrified office started serving other functions (e.g., library and conference room).

These identified experiences of the schools in the improved day-to-day operations and enhanced functionality of facilities strengthen the argument of Lenz, et al. (2017) that access to electricity improves administrative processes and educational services of schools.

Maintenance and safety considerations. As much as possible, all classrooms were electrified, but not all were installed with sockets for safety and monitoring reasons. Some classrooms were not provided with outlets to avoid overloading. Usually, outlets are only available in the administration or school head's office to monitor usage.

To maintain the solar panels, the schools would either hire or appoint a dedicated custodian. It can be an external utility or technician, or an internal coordinator who is either a volunteer or a designated teacher. Currently, a number of schools rely on the cooperation and voluntarism of parents and other community members in the maintenance of solar technology. Parents help through regular *Brigada* (volunteer brigade) activities. In any case, the cleaning procedures they follow are primarily based on the training they received from OMF at the start of the program.

The budget for the maintenance comes from PTA contributions ranging from PHP 50 to PHP 120/year per parent. The amount is usually kept by the treasurer and earmarked specifically to maintain the inverter, batteries, or purchase gasoline for a backup generator. One school has taken one step further by including maintenance expenses in the budget proposal that is submitted to the division office.

In general, the teachers find the technology safe. Reliability is sometimes affected by weather conditions, as well as the intensity of use, something that they have learned to deal with over time:

> *Pag tag-ulan, ano konti-konti lang po ang gamit ng kuryente, tipid tipid sa paggamit halimbawa ng* laptop *o sa pagpanood ng* TV.(During the rainy season, we try not to consume electricity that much; we try to save by limiting the use of laptop or TV.)

The experiences of the beneficiary schools in maintaining the solar facility highlights the findings of Pueyo et al. (2014) and Brooks and Urmee (2014) on the importance of integrating continuous maintenance in the business model to sustain the operation of renewable energy.

Other Positive Externalities

Improved school safety. Electrification has improved the level of security in some of the schools. This is particularly important for schools where theft has been reported in the past. The school head from Cayabu shared that: "Kahit papaano ay maiiwasan na ang magnanakaw sa school. (At least, we will be able to keep thieves away.)"

This has also assuaged the fears of parents in Cayabu about late-night scouting activities on the school grounds. With the electrification, more parents now allow their children to join in the activity.

This sense of security was also felt by the teachers. From Parang Cueva, a teacher shared that:

> *Dati ay nakakatakot maglakad or mag-*stay *sa* school *kapag madilim. Ngayon hindi na dahil may ilaw na.* (Before, it was scary to walk or stay in the school because it was dark. Now it is no longer the case since we have light.)

*Fostering camaraderie***.** The program also has positive spillover effects on the socialization behavior of teachers. With new equipment available in the teachers' office (e.g. electric fan, TV, computer, printer, etc.), teachers are encouraged to socialize more often. As reported in one school: "*Sa* office *malaking pagbabago, laging napupuno* jam-packed *kami kasi may kuryente*. (There have been noticeable changes in the office; we are now always jam-packed because we have electricity.)"

It also opened up avenues for peer-to-peer mentoring, especially concerning computer literacy. This was particularly the case with Lubol:

> *Hindi kasi lahat ng* teachers *ay* computer literate so because of that *tinuturuan sila ng kapwa* teacher *nila.* Before *hindi marunong pero ngayon marunong na.* (Not all teachers are computer literate, so their fellow teachers help them. Before, they don't know much; now, they already know how to use computers properly.)

*Other Functions for the Community***.** The schools also serve other important functions for the community since electrification. Some schools served as evacuation centers during emergencies, venues for barangay assemblies, and meeting venues for other groups or organizations. For community members who do not have access to electricity, some schools allow them to charge their electronic gadgets and print and photocopy educational materials for a fee. Occasionally, the schools also earn from the use of facilities by different groups. The PTA manages the money generated from these activities mainly for the maintenance of the solar facility.

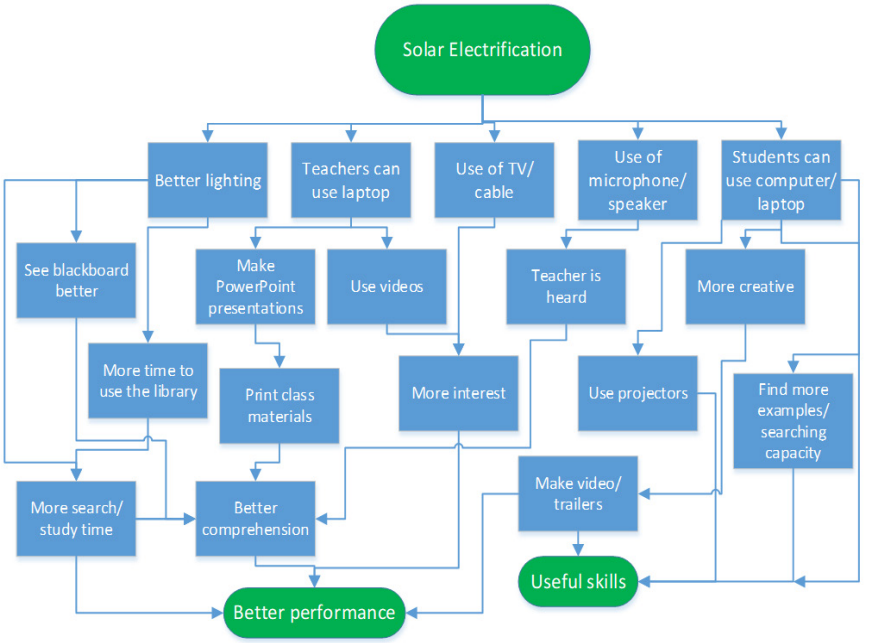
Conclusion

How can we summarize the impact of school electrification based on the results? Figure 2 provides an illustrative diagram of the change based on the qualitative statements of the stakeholders (i.e., school heads, teachers, students, and parents).

The more direct impact of electrification is to provide a better environment for learning. From as simple an effect as providing for better lighting, students can see the blackboard better and use the library longer. They could also provide electric fans, which make the environment in the room cooler and more conducive to learning.

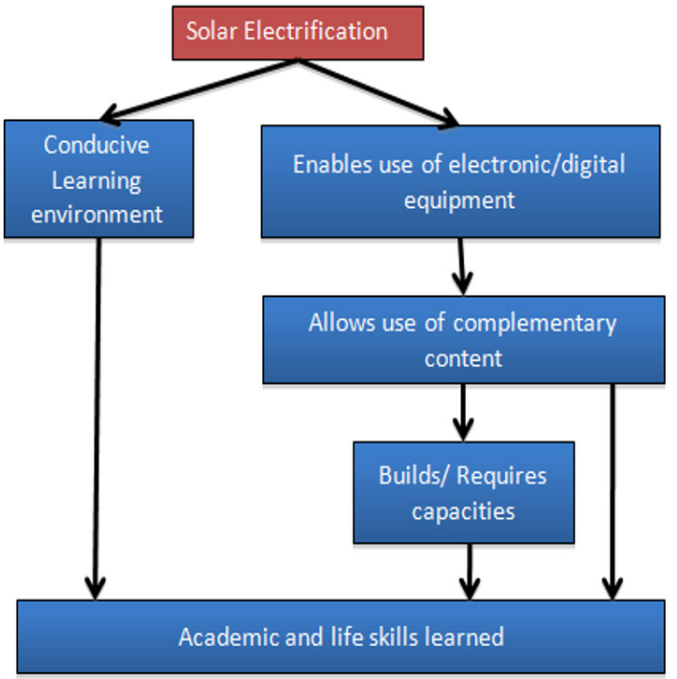
It enables the use of equipment for improved teaching and learning experience, such as televisions, projectors, laptops, and microphones. This, in turn, allows them to use multi-media content, which complements their curricula in many subjects (e.g., English, Science, Math, Filipino, Music, AP, etc.). The richer the content of the lesson is, the more interesting and engaging for the students, which in turn motivating them and encouraging attendance.

Figure 2
Mind Map of Impact Change



The findings also show that access to electricity increases efficiency, as it reduces the time and costs for teachers to prepare their teaching materials and perform other administrative matters in school (although this did not consider the cost of getting a laptop and access to the internet). This proves to be less costly because they no longer had to spend on photocopying, pay for transportation to use a computer, or spend on materials such as manila paper. They also have an easier time organizing their materials and do not have to keep preparing the same materials manually on manila paper or re-write it on the board.

Figure 3
Theory of Change



As a result of the electrification of their schools, the expectations of students have also increased in terms of the quality of instruction and use of other materials, equipment, and their own school submissions.

As such, this has also led to additional costs such as printing of outputs, photocopying of materials, transportation (to have access on the internet in the nearby barangays) and internet access. Unless internet access would be made available in the school, the cost of internet access and, to a certain extent, transportation can be considered recurring expenses for the parents and the students.

While all classrooms are lighted, that is not the sole purpose of electricity. The availability of electrical equipment (e.g., TV, laptop, projector, music player etc.) due to electrification has led to increased demand for energy. As a result, many schools want more solar panels to support additional demand/use for electricity. Access to these equipment causes the demand of internet access to maximize their functionality.

Recommendations

Electricity allows for new equipment to be introduced (e.g., TV, laptop, lights, fan), and opens opportunities for stakeholders to start thinking of other needs (e.g., digital/online learning facilities, technical-vocational education materials, etc.) that can be put in the school. Sourcing these are crucial to teaching innovations.

As such, schools and other stakeholders should consider asking for packages or develop proposals asking for equipment and capability building that can help maximize the impact of electrification. In some cases, schools were able to access smart TVs from their local political leaders, and/or voluntary organizations.

Eventually, the provision of electricity leads to more uses and more users. Hence this would also lead to demand for more electricity over time. This has both practical and administrative implications. School heads and other key stakeholders (e.g., LGUs, DepEd, parents, and other partner organizations) should be able to anticipate the corresponding demands that come with more uses and more users (e.g., additional solar panel, equipment, and cable and internet access). Sourcing these demands is therefore vital and should also be taken into consideration in tapping existing collaborations and establishing new ones. Hence, the sustainability of the program also entails projecting future demand and the related technical and financial costs this would entail.

Regular training for all teachers on the value and maintenance of solar panel technology was likewise raised by teachers and school administrators. They consider this to be important since teachers get “rotated” or transferred to other schools now and then, and most schools do not have the financial capacity to pay for a dedicated technical staff over the long term. This can also benefit new teachers who were not yet around when OMF conducted its training. Assigning teachers for the maintenance of the solar facility should be done with due consideration on the main responsibilities of teachers as educators and other administrative tasks.

Moreover, some of the beneficiary schools recommended that orientation programs be held periodically for parents and the community in general. In the absence of readily available technical support in the area, this social buy-in

needs to be continually secured and reinforced to leverage the limited resources of the schools together with the willingness of the community to provide additional support. Continuous maintenance should be a collaboration among all the stakeholders. Considering the rotation being done with school heads and teachers where there is a big possibility that they will be transferred to other schools, the support and awareness of local community members (e.g., parents, local officials, CSOs) on the proper maintenance of the solar facility cannot be overly emphasized.

By and large, the current limitations of the solar electrification program can be viewed as an opportunity for schools to prepare proposals for additional funding. One can note, for instance, that these may be relatively small investments that they can also request from the LGUs' local school board, or perhaps even the parent-teacher association. In other words, electrification has helped expand the opportunities for other stakeholders to get involved and collaborate in improving education in rural areas. As such, strategic collaboration among these stakeholders should be established to encourage commitment towards effectively working together.

Finally, future research can focus on the quantitative data (e.g., scores in national achievement tests, completion rate, etc.), which can complement this study and further determine the impact of school electrification on learning. As such, it would be ideal to establish benchmark measurements of school performance before their electrification and to track data on this over a period of time.

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