CROSSING OVER

THE ENERGY TRANSITION TO RENEWABLE ELECTRICITY

SECOND EDITION

FRIEDRICH EBERT STIFTUNG

ROBERTO S. VERZOLA

CROSSING OVER

The energy transition to renewable electricity

Second Edition

Roberto S. Verzola

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Crossing Over: *The Energy Transition to Renewable Electricity*

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To Antonio Nepomuceno, whose
vision of a solar-powered society
is a continuing inspiration

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Foreword

The Philippines is not foreign to the effects of global warming. Year after year, the country is beset by typhoons that only get stronger and more devastating. This year saw one of the most severe episodes of El Niño that caused a drought in Mindanao. As the Philippines is one of the countries most affected by climate change, Filipinos understand that taking preventive action against global warming is already urgent.

However, the Philippines faces another dilemma: that of the inaccessibility of energy in the country. Local electricity rates remain the highest in Asia. Scheduled brownouts still are the norm in regions outside Manila. This lack of energy security, coupled with high energy costs, serve as the greatest barrier for the country to fulfil its dream of becoming industrialized. Given this situation, the quick-fix but ultimately unsustainable solution of building more fossil fuel plants remains tempting for policymakers.

Through the efforts of Filipino thought leaders, the Philippine society is now slowly realizing that choosing renewable energy sources is not only good for the planet, but also is the most economically rational choice in the long term. Both in the West and the East, new technologies in solar, wind, and energy storage are being developed to bring the cost of renewable energy down. Locally, pioneering local government units are already working with civil society and industry to add more renewable energy sources to the mix. We already have the proof of concept that a full transition to renewables is possible – we just have to make the political and social environment favourable for the transition.

The Friedrich-Ebert-Stiftung is happy to be part of this emerging energy revolution. Since 2012, Friedrich-Ebert-Stiftung has been working with local partners to pursue an urgent and sustained shift towards an energy mix that avoids the use of coal and nuclear power sources, which are highly-dangerous and environmentally-degrading, and maximizes the Philippines' vast resources of renewable energy. One of these projects, through the effort of Engineer Roberto Verzola, was the publication of the first edition of *Crossing Over*, a landmark study that details the steps that we must take towards an energy transition. Due to the positive reviews on the first edition of *Crossing Over*, and the rapid changes that happened in the Philippine energy sector since then, we saw the need to publish a second edition.

Once again, Friedrich-Ebert-Stiftung would like to thank Engr. Verzola for his tireless pursuit towards a fully clean and renewable energy future for the Philippines. We also thank his colleagues in his organization, the *Center for Renewable Electricity Strategies*, for their immeasurable contribution to the energy transition through the implementation of some of the ideas that Engr. Verzola emphasized in the first edition of this book.

We encourage the readers to join us in making the recommendations in this study a reality.

Berthold Leimbach
Resident Representative
Friedrich-Ebert-Stiftung – Philippine Office

Preface

Many studies on renewable energy (RE) in the Philippines have already been done. This particular study on RE is focused on strategies that can lead to a full transition of electricity generation in the country from non-renewable to renewable energy.

This study paints in broad strokes a picture of the RE situation in the country's electricity sector. It includes enough highlights to give potential adopters and investors a sense of the terrain in terms of the physical, economic and institutional contexts within which they would be working.

This study also provides some criteria that can help local officials assess their locality's endowments in renewable electricity generation. If they find that they are well-endowed, and they are interested in hosting or setting up themselves an RE showcase in their area, then they should take immediate steps towards making a more thorough assessment of the technical and financial feasibility of such a showcase.

The specific goal of this study is to map out a process that will lead to at least one locality—or hopefully several—becoming a showcase for 100% renewable electricity in the Philippines.

Showcasing RE in some localities, it must be emphasized, is a strategy, not an end-goal. The goal is a nationwide shift to RE. Not overnight, of course, but as quickly as we can realistically make it.

The goal above is inspired by the experience of the village of Feldheim in Germany. In this village, 100% of the power for heating and electricity are sourced from renewable sources. The residents benefit from local electricity rates that are lower than the rates charged by the grid—and the village gets additional income from selling its excess electricity production to the grid!

The Feldheim model was of course made possible by a confluence of events and conditions specific to Germany, not all of which can be readily replicated in the Philippines.

Through this and follow-up studies, we want to identify events and conditions and set into motion the processes that would lead to Feldheim-type showcases in the Philippines: 100% renewable, competitive local rates and financially viable.

Lest someone claim that 100% renewable is a pipe dream, the table below lists studies that have been done in some developed economies to confirm the possibility of a fully renewable future in their own country.[2] The list shows that other countries are thinking of the same thing.

Title of Study	Year pub.	Organization	Target Year	Energy Mix
Solar Sweden: An Outline to a Renewable Energy System	1977	Secretariat for Future Studies	2015	61.8% biomass, 12.5% solar heat; 11.4% water power, 8.8% PV, 5.3% wind, 0.2% ocean energy
ALTER: A Study of a Long-Term Energy Future for France Based on 100% Renewable Energies	1978	Le Groupe de Bellevue (scientific group of leading research institutes	2050	49.5% solar, 27.2% biomass, 13.7% water power, 5.1% tide power, 4.6% wind power

2 Hermann Scheer, *Energy Autonomy: The Economic, Social and Technological Case for Renewable Energy*. (London: Earthscan, 2007), p. 50-51.

Energy Strategies: Towards a Solar Future (U.S.)	1980	Union of Concerned Scientists	2050	
Solar Energy Futures in a Western European Context	1982	International Institute for Applied Systems (IIASA)	2100	33.9% wind power, 28.3% on-site, 15.1% biomass, 9.4% PV, 8.5% water power, 3.4% solar-H_2, 1.4% wave power
Renewable Energy Supply under Conditions of Globalization and Liberalization	2002	Survey Commission of the German Bundestag	2050	84.6% local renewables; 15.4% imported renewables
Energy Rich Japan (ERJ)	2003	Institute for Sustainable Solutions and Innovations (ISUSI)	2050	35.1% solar, 28.4% wind, 17.7% CHP, 13.5% geothermal, 5.2% water power

In fact, two countries have passed laws mandating 100% renewable electricity: by 2020 for Scotland,[3] and by 2035 for Denmark.[4]

And it has been a reality in at least one country since 2011. Iceland gets its electricity from hydroelectric (75%) and geothermal (25%) sources only.[5] No fossil fuels, no nuclear plants, 100% renewable.

For these countries, 100% renewable electricity is not just a dream anymore.

3 http://www.go100percent.org/cms/index.php?id=70&tx_ttnews[tt_news]=39.

4 http://www.go100percent.org/cms/index.php?id=19&id=69&tx_ttnews[tt_news]=109&tx_locator_pi1[startLat]= 45.93583305&tx_locator_pi1[startLon]=-4.86260045&cHash=215730a0771059056e307660236a46c9.

5 http://www.go100percent.org/cms/index.php?id=45&tx_ttnews[tt_news]=242&cHash= e34b862ab4318c0d956f7d0d3facad9a.

Acknowledgments

Renewable energy has been a long standing interest of mine, ever since I was a teen, ages ago. I would get drawn back to this interest again and again, despite diversions along the way.[1]

In the 1980s, it was the Bataan Nuclear Power plant, with the Freedom from Debt Coalition and the Nuclear-Free Philippines Coalition that got me involved in energy issues. In the 1990s, it was solar energy, with the late Bishop Antonio Nepomuceno, who became a dear friend, and the non-profit group that he initiated, Soljuspax. It was Bishop Nep's dream—our group's dream—to build a manufacturing facility for photovoltaic panels in the Philippines. But he died in a tragic plane crash before he realized this dream. We did manage to make some solar cookers and give away some solar panels. I installed one of them at the Center for Ecozoic Living and Learning, a permaculture farm in Barangay Malaking Tatiaw, Silang, Cavite. The center was set up by another dear friend, Fr. John Leydon of the Columban Fathers. In the late 1990s and early 2000s, I experimented with water power, particularly in ram pumps, fashioning a working model using ordinary valves, pipes and tanks you could buy from a hardware store. I successfully tested the ram pump in my wife's remote village in Barangay Casispalan, Tagkawayan, Quezon. But I never got to the mass production and mass promotion stage. I still have the designs with me.

Other issues—equally important, I must say—intervened and drew me away from more active work on renewable energy. So I watched the developments from a distance, with deep interest but without the time needed to give it justice if I were to get involved deeply. Just the same, whenever I got an occasional invitation in fora to talk about nuclear power and renewable energy, I would talk about increasing nuclear power costs and decreasing solar/wind costs and the cross-over point between the two. I would never forget about the cross-over point.

Then the Active Citizenship Foundation involved me into a series of conferences on energy and climate change, culminating in a trip to Feldheim, a little village in Germany. This village draws all its electricity from the sun, the wind, biogas and occasional burning of woodchips—sources that are all renewable. It was not only an eye-opening trip for me. It was also a life-changing one. I decided then that renewable energy, once more, should become one of my priorities. This advocacy fits perfectly into my ecological and social justice advocacies. Like my other current advocacies on (organic rice farming methods and free software), it is also a positive advocacy, a departure from the "expose and oppose" advocacies that occupied me in the past. Furthermore, renewable energy advocacy fits right into my theoretical studies on the economics of abundance.

Still, I would not have gotten back so quickly into the thick of the renewable energy advocacy if Berthold Leimbach of the Friedrich Ebert Stiftung had not provided the perfect opportunity to do so, by asking me to do this study. Berthold must have seen the twinkle in my eyes, as I saw in his, when we talked about renewable energy. I said yes right away.

This study would not have been possible without my partnership with Prof. Miguel Escoto Jr. of the University of the Philippines (UP) College of Engineering and head of the UP Solar Photovoltaic Laboratory. My friendship with Mike goes a long way, ever since my student days at the College in the late 1970s. He let me play with the TRS-80 microcomputer in the EE Laboratory that nobody else seems to have found interesting enough. It was Mike's little kindness of lending me the key to the lab that set me off in the direction of computers and information technology. Mike should be listed as co-author of this study, but I didn't want to put him in the awkward position of defending the more strongly-worded formulations that I

felt were needed to emphasize some of our findings. But this study would not have been possible without the data, analysis and advice that he had provided.

My thanks also to the two other members of our research team, Engr. Leo Tayo and Atty. Ma. Ronely Bisquera-Sheen. Dr. Eddie Dorotan of the Galing-Pook Awards was also very helpful in arranging meetings with some government officials, and agreed to be part of an advisory group that will continue to promote the idea of RE showcases throughout the country.

My thanks, furthermore, to all those who attended the forum sponsored by the Friedrich Ebert Stiftung and the UP Solar PV Laboratory, especially Rosario Venturina of the National Renewable Energy Board, Theresa Cruz-Capellan of the Philippine Solar Power Alliance, and Ma. Teresa Diokno of Center for Power Issues and Initiatives, who came as reactors, and the others who gave their comments during the forum or to me in private.

My thanks, finally, to Josua Mata of the Sentro ng Nagkakaisa at Progresibong Manggagawa and the Alliance of Progressive Labor for putting me in touch with union leaders in the electricity industry, who shared with me the labor sector's perspective of the industry. I wish him and his fellow labor leaders success in their heroic efforts at organizing the labor sector.

For this edition of the book, I thank the Friedrich Ebert Stiftung for finding it worthy of a second edition. I also thank Renee Tumaliuan of FES for patiently following me up to finish my writing soon. I have missed too many deadlines. I'm really glad to tell Renee it is finally done.

To all the others who helped and encouraged me along the way, my heartfelt thanks.

Roberto S. Verzola
January 29, 2015
rverzola@gn.apc.org

List of Abbreviations

AC	Alternating current
BOI	Board of Investments
BOS	Balance of system
CAPEX	Capital expenditure (or expense)
CEPALCO	Cagayan Electric Power and Light Company, Inc.
DC	Direct current
DENR	Department of Environment and Natural Resources
DOE	Department of Energy
DOST	Department of Science and Technology
DU	Distribution Utility
EDU	Exploration, development and utilization
EPIRA	Electric Power Industry Reform Act
ERC	Energy Regulatory Commission
EPI	Emerging Power, Incorporated
FES	Friedrich Ebert Stiftung
FIT	Feed-in tariff
FIT-ALL	Feed-in-tariff allowance
FPIC	Free and prior informed consent
FTAA	Financial or Technical Assistance Agreement
GEF	Global Environment Facility
GENCO	Generation company
GFI	Government financial institution
GHG	Greenhouse gas
GIZ	Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatts (one billion watts)
GWh	Gigawatt-hours
Ha	Hectare(s)
IPP	Independent power producer
IRR	Internal rate of return
kW	Kilowatt
kWh	Kilowatt-hour
kWp	Kilowatt-peak
LED	Light-emitting diode
LGU	Local government unit
m^2	Square meter
m/sec	Meter(s) per second
Meralco	Manila Electric Company

Mo	Month
MPPT	Maximum Power Point Tracking
MW	Megawatt (one million watts)
MW	Megawatt-hour
NEM	Net energy metering
NCIP	National Commission on Indigenous Peoples
NGCP	National Grid Corporation of the Philippines
NGO	Non-government organization
NREB	National Renewable Energy Board
NREL	National Renewable Energy Laboratory, U.S.
NSO	National Statistics Office
O&Me	Operating and maintenance
PDP	Power Development Program
PEMC	Philippine Electricity Market Corporation
PEP	Philippine Energy Plan
PEPOA	Philippine Electricity Power Operators Association
POP	Peak/Off-peak
PPA	Power purchase agreement
PSPA	Philippine Solar Power Alliance
PV	Photovoltaic
RE	Renewable energy
REMB	Renewable Energy Management Bureau
RESC	Renewable energy service contract
ROI	Return on investment
RPS	Renewable portfolio standards
SACASOL	San Carlos Solar Corporation
SEC	Securities and Exchange Commission
SHS	Solar home system
SIBAT	Sibol ng Agham at Teknolohiya
SME	Small- and medium-scale enterprise
TAREC	Trans-Asia Renewable Energy Corporation
TOU	Time of use
UP	University of the Philippines
V	Volts
VAT	Value-added tax
WEDAP	Wind Energy Development Association of the Philippines
Wp	Watt-peak
WESM	Wholesale Electricity Spot Market

Chapter 1
Electricity: Solar is now cheaper than coal!

"As a simple example, the cost of electricity from a coal plant can run up to ₱5.50 per kilowatt-hour, plus ₱6.50 for distribution and transmission, which amounts to ₱12.00. If you install solar panels on your rooftop, you will only spend ₱9.00 per kilowatt-hour for generation and no cost for distribution or transmission. This already saves you up to ₱3 per kilowatt-hour."

– **Carlos Jericho L. Petilla,** *Department of Energy Secretary (2010-2016), August 2014* [6]

The conventional wisdom was probably true a decade ago, that among the various sources of electricity, solar panels were the most expensive. The impression of many that electricity from solar panels were still more expensive than electricity from coal plants might have been true a few years ago.[7]

But things have changed.

As former Energy Secretary Petilla himself calculated, electricity generated from a coal plant and delivered through the national grid cost consumers around twelve pesos per kilowatt-hour, while the same amount of electricity generated from solar panels on one's rooftop cost only nine pesos, a cost advantage of three pesos per kilowatt-hour. That was in 2014.

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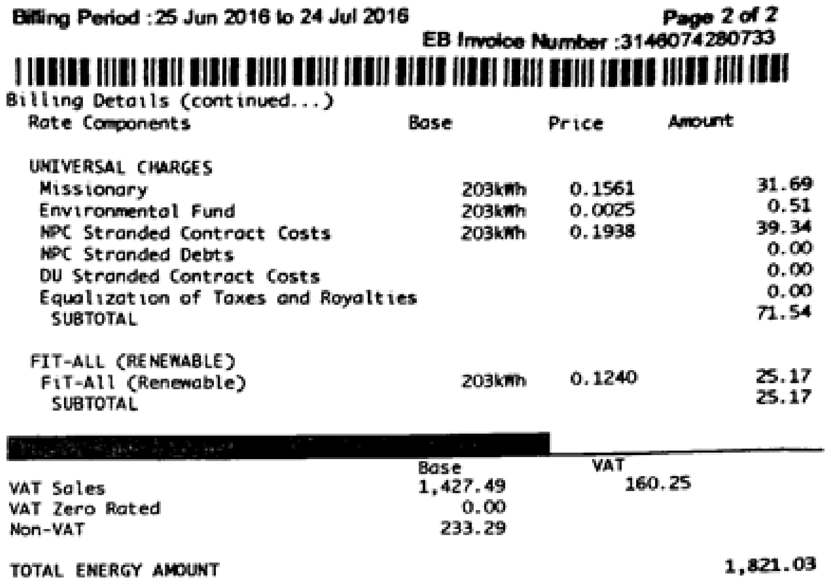
6 DOE Sec. Petilla: Renewables Pave the Way to Energy Security in the Philippines," Department of Energy, (Accessed January 29, 2015), http://www.doe.gov.ph/news-events/events/announcements/2473-doe-sec-petilla- renewables-pave-the-way-to-energy-security-in-the-philippines.

7 It was not true either, if the health, social and environmental costs of coal mining, transport and burning were fully taken into account.

Let us look at the situation today. Figure 1 shows part of a July 2016 bill from Metro Manila's electric utility Meralco:

Figure 1. A Meralco electric bill, July 2016



Billing Period :25 Jun 2016 to 24 Jul 2016 Page 2 of 2

EB Invoice Number :3146074280733

Billing Details (continued...)

Rate Components	Base	Price	Amount
UNIVERSAL CHARGES			
Missionary	203kWh	0.1561	31.69
Environmental Fund	203kWh	0.0025	0.51
NPC Stranded Contract Costs	203kWh	0.1938	39.34
NPC Stranded Debts			0.00
DU Stranded Contract Costs			0.00
Equalization of Taxes and Royalties			0.00
SUBTOTAL			71.54
FIT-ALL (RENEWABLE)			
FiT-All (Renewable)	203kWh	0.1240	25.17
SUBTOTAL			25.17

	Base	VAT	
VAT Sales	1,427.49	160.25	
VAT Zero Rated	0.00		
Non-VAT	233.29		
TOTAL ENERGY AMOUNT			1,821.03

Source: Photo by the author

There are lots of interesting information on an electric bill, but we will at this time focus only on the retail price: ₱1,821.03 for 203 kWh, or ₱8.97 per kWh (19.1 US cents, at ₱47/$). Note that the price of electricity in 2016 is 25% lower than in 2014, reflecting mostly the decrease in oil prices over the period.

Let us now estimate the cost of solar electricity from one's rooftop, using the standard method called levelized cost of electricity (LCOE). This method is used to compare the cost of electricity from various sources. LCOE involves totaling in today's prices (i.e., the net present value) all the expenses incurred in procuring, operating and maintaining a rooftop solar PV system throughout its lifetime. We describe the simplest setup possible: solar panels connected to a grid-tie inverter, the inverter connected to a household electric outlet, and no batteries.

Let us list all these expenses:

₱100,000.00 1 kWp of solar panels, grid-tie inverter, and miscellaneous hardware
₱ 90,000.00 replacement grid-tie inverters (two replacements over a 20-year period)
₱ 50,000.00 operating and maintenance expenses (2.5% of capital cost per year x 20 years)-
----
₱240,000.00 Total lifetime cost of the system

The numbers above are based on the assumptions that grid-tie inverters will still cost as much as the panels themselves (they now tend to cost less) and that lifetime O&M expenses will be 50% of the initial capital cost of the system (25% was used in the first edition). A higher figure was used because O&M costs will not necessarily track the decline in capital costs.

Let us now calculate the lifetime output of the system from the following data/assumptions:

4.5 peak-hours per day, on the average
365 days per year (most accountants use 360)
20 years system life
85% system efficiency

Multiplying the four together (4.5 x 365 x 20 x .85) gives a total lifetime output of 27,922.5 kWh.

Dividing the lifetime cost by the lifetime output gives the levelized cost of electricity (LCOE) from rooftop solar panels of ₱8.60, which is still slightly better than the ₱8.97 retail price of electricity in Metro Manila. In fact, Meralco rates in 2016 went below eight pesos, but rose again and by July 2016 was approaching nine pesos. Former Secretary Petilla's conclusion was a robust one: electricity from solar rooftops was still generally cheaper than grid-delivered electricity, despite a 25% decrease in utility rates.

Electricity cost ₱8.97/kWh in Metro Manila as of July 2016. The rates in other parts of the Philippines are given in the following tables. Note that the given rates are for a particular month (although not indicated), not average rates. They may be different today.

The 22 service areas out of 124 where utility rates are still lower than solar rooftop costs are highlighted in blue, the darker the highlight, the lower the utility rate.

In the Ilocos region, the highest rate is charged by the Pangasinan Electric Cooperative 1 (₱17.7595) and the lowest by the La Union Electric Cooperative (₱7.9260)

Table 1: Electricity rates in the Ilocos Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
ILOCOS			
CELCOR	Cabanatuan Electric Corporation	8.3742	9.735
CENPELCO	Central Pangasinan Electric Cooperative	9.5055	10.0012
DECORP	Dagupan Electric Corporation	8.0806	8.0806
INEC	Ilocos Norte Electric Cooperative	9.2587	9.0452
ISECO	Ilocos Sur Electric Cooperative	8.8764	8.907
LUELCO	La Union Electric Cooperative	7.92601	9.2427
PANELCO 1	Pangasinan I Electric Cooperative	7.7595	8.251
PANELCO 3	Pangasinan III Electric Cooperative	9.6275	10.9763

Source: kuryente.org.ph

In the Cordillera Administrative Region, the highest rate is charged by the Kalinga-Apayao Electric Cooperative (₱12.6595) and the lowest by the Benguet Electric Cooperative (₱8.1432).

Table 2: Electricity rates in the Cordillera Administrative Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
CAR			
ABRECO	Abra Electric Cooperative	8.7422	10.5673
BENECO	Benguet Electric Cooperative	8.1432	8.2734
IFELCO	Ifugao Electric Cooperative	10.1145	11.0829
KAELCO	Kalinga Apayao Electric Cooperative	12.6595	12.6595
MOPRECO	Mountain Province Electric Cooperative	10.5302	10.1613

Source: kuryente.org.ph

In the Cagayan Valley Region, the highest rate is charged by the Nueva Vizcaya Electric Cooperative (₱10.3056) and the lowest by the Isabela Electric Cooperative 1 (₱8.9117).

Table 3: Electricity rates in the Cagayan Valley Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
CAGAYAN VALLEY			
BATANELCO	Batanes Electric Cooperative	10.1256	
CAGELCO 1	Cagayan I Electric Cooperative	9.7545	11.1012
CAGELCO 2	Cagayan II Electric Cooperative	10.1523	10.902
ISELCO 1	Isabela I Electric Cooperative	8.9117	11.8912
ISELCO 2	Isabela 2 Electric Cooperative	9.7222	9.4222
NUVELCO	Nueva Vizcaya Electric Cooperative	10.3056	10.3056
QUIRELCO	Quirino Electric Cooperative	9.4275	10.5559

Source: kuryente.org.ph

In Central Luzon Region, the highest rate is charged by the Aurora Electric Cooperative (₱10.8586) and the lowest by the Pampanga Electric Cooperative 1 (₱7.2627).

Table 4: Electricity rates in the Central Luzon Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
CENTRAL LUZON			
AEC	Angeles Electric Corporation	8.5200	9.59
AURELCO	Aurora Electric Cooperative	10.8586	16.2642
NEECO 1	Nueva Ecija I Electric Cooperative	8.5518	9.2633
NEECO 2-Area I	Nueva Ecija II- Area I Electric Cooperative	9.2573	9.1854
NEECO 2-Area II	Nueva Ecija II- Area II Electric Cooperative	9.2018	8.6742
OEDC	Olongapo City - Public Utilities Department	8.6566	8.6774
PELCO 1	Pampanga I Electric Cooperative	7.2627	7.6001
PELCO 2	Pampanga II Electric Cooperative	10.4759	8.6091
PELCO 3	Pampanga III Electric Cooperative	10.0954	10.0954
PENELCO	Peninsula Electric Cooperative	7.6650	8.9658
PRESCO	Pampanga Rural Electric Service Coop.	8.0436	9.4929
SAJELCO	San Jose City Electric Cooperative	9.0823	8.9667
SFELAPCO	San Fernando Electric Light & Power Co.	9.6919	9.6919
TARELCO 1	Tarlac I Electric Cooperative	9.1085	8.52
TARELCO 2	Tarlac II Electric Cooperative	8.4773	9.4814
TEI	Tarlac Electric	9.8300	10.2229
ZAMECO 1	Zambales I Electric Cooperative	8.4280	8.4726
ZAMECO 2	Zambales II Electric Cooperative	9.0477	9.0477

Source: kuryente.org.ph

In Southern Tagalog Region, the highest rate is charged by the Ibaan Electric & Engineering Cooperative II (₱10.7553) and the lowest by the Quezon Electric Cooperative I (₱7.8374).

Table 5: Electricity rates in the Southern Tagalog Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
SOUTHERN TAGALOG			
BATELEC 1	Batangas I Electric Cooperative	9.9353	9.9353
BATELEC 2	Batangas II Electric Cooperative	8.2966	9.6047
FLECO	First Laguna Electric Cooperative	8.9805	10.1229
IEEC	Ibaan Electric & Engineering Corp.	10.7553	10.7553
QUEZELCO 1	Quezon I Electric Cooperative	7.8374	10.3698
QUEZELCO 2	Quezon II Electric Cooperative	10.5779	11.4683
QUEZELCO 2 (SPUG JOMALIG)	Quezon II Electric Cooperativ		10.2583
QUEZELCO 2 (SPUG PATNANUNGAN)	Quezon II Electric Cooperativ		9.8666
QUEZELCO 2 (SPUG POLILLO)	Quezon II Electric Cooperativ		11.5879

Source: kuryente.org.ph

In the MIMAROPA Region, the highest rate is charged by the Lubang Electric Cooperative (₱14.1551) and the lowest by the Tablas Island Electric Cooperative 1 (₱9.4417).

Table 6: Electricity rates in the MIMAROPA Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
MIMAROPA			
BISELCO	Busuanga Island Electric Cooperative	10.3819	
LUBELCO	Lubang Electric Cooperative	14.1551	
MARELCO	Marinduque Electric Cooperative	10.1395	
OMECO	Occidental Mindoro Electric Cooperative	11.3911	
ORMECO	Oriental Mindoro Electric Cooperative	11.2366	
PALECO	Palawan Electric Cooperative	10.7817	
ROMELCO	Romblon Electric Cooperative	10.6646	
TIELCO	Tablas Island Electric Cooperative	9.4417	

Source: kuryente.org.ph

Bicol Region data for 2016 was not available. Only 2014 data is shown below, when the highest rate was charged by the Camarines Sur Electric Cooperative IV (₱12.2664) and the lowest by the Camarines Sur Electric Cooperative II (₱9.1449).

Table 7: Electricity rates in the Bicol Region, 2014

Acronym	Distribution Utility	2016 price	2014 price
BICOL			
ALECO	Albay Electric Cooperative		10.7715
ALECO (SPUG)	Albay Electric Cooperative		10.328
CANORECO	Camarines Norte Electric Cooperative		19.1924
CASURECO 1	Camarines Sur I Electric Cooperative		11.3296

CASURECO 2	Camarines Sur II Electric Cooperative		9.1449
CASURECO 3	Camarines Sur III Electric Cooperative		11.9053
CASURECO 4	Camarines Sur IV Electric Cooperative		12.2664
SORECO 1	Sorsogon I Electric Cooperative		9.6901
SORECO 2	Sorsogon II Electric Cooperative		10.8842

Source: kuryente.org.ph

In the Western Visayas Region, the highest rate is charged by the Capiz Electric Cooperative (₱13.2241) and the lowest by the Northern Negros Electric Cooperative (₱9.4865).

Table 8: Electricity rates in the Western Visayas Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
WESTERN VISAYAS			
AKELCO	Aklan Electric Cooperative	10.6849	10.6849
ANTECO	Antique Electric Cooperative	11.6007	11.6007
CAPELCO	Capiz Electric Cooperative	13.2241	13.2241
CENECO	Central Negros Electric Cooperative	9.5663	9.25
GUIMELCO	Guimaras Electric Cooperative	13.0144	15.4811
ILECO 1	Iloilo I Electric Cooperative	11.3442	11.3442
ILECO 2	Iloilo II Electric Cooperative	10.9465	10.3287
ILECO 3	Iloilo III Electric Cooperative	11.5439	11.5439
NOCECO	Negros Occidental Electric Cooperative	10.8017	10.2913
NONECO	Northern Negros Electric Cooperative	9.4865	12.9232
PECO	Panay Electric Company	10.7627	10.7627

Source: kuryente.org.ph

In the Central Visayas Region, the highest rate is charged by the Camotes Electric Cooperative (₱14.9330) and the lowest by the Cebu Electric Cooperative 3 (₱7.2339).

Table 9: Electricity rates in the Central Visayas Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
CENTRAL VISAYAS			
PROSIELCO	Prov. of Siquijor Electric Cooperative	11.7684	
BANELCO	Bantayan Electric Cooperative	11.6220	
BLCI	Bohol Light Company	8.5427	8.4722
BOHECO 1	Bohol I Electric Cooperative	8.9581	8.9581
BOHECO 1 (Cabilao Island)	Bohol I Electric Cooperative		8.6554
BOHECO 2	Bohol II Electric Cooperative	8.9012	8.9012
CEBECO 1	Cebu I Electric Cooperative	9.8699	10.3888
CEBECO 2	Cebu II Electric Cooperative	9.8731	9.2882
CEBECO 3	Cebu III Electric Cooperative	7.2339	6.9403
CELCO	Camotes Electric Cooperative	14.9330	
MECO	Mactan Electric Company	8.3135	9.0239
NORECO 1	Negros Oriental I Electric Cooperative	9.1339	11.2127
NORECO 2	Negros Oriental II Electric Cooperative	10.7749	10.7749
VECO	Visayan Electric Company	10.8584	11.1116

Source: kuryente.org.ph

In the Eastern Visayas Region, the highest rate is charged by the Leyte Electric Cooperative III (₱11.8759) and the lowest by the Leyte Electric Cooperative II (₱8.0622).

Table 10: Electricity rates in the Eastern Visayas Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
EASTERN VISAYAS			
BILECO	Biliran Electric Cooperative Inc.	11.0799	9.2272
DORELCO	Don O.Romualdez Electric Coperative	9.7626	9.7626
ESAMELCO	Eastern Samar Electric Cooperative	10.0289	10.0289
LEYECO 2	Leyte II Electric Cooperative	8.0622	8.0622
LEYECO 3	Leyte III Electric Cooperative	11.8759	11.8759
LEYECO 4	Leyte IV Electric Cooperative	9.8332	9.8332
LEYECO 5	Leyte V Electric Cooperative	9.1003	9.1003
NORSAMELCO	Northern Samar Electric Cooperative	10.6834	10.6834
SAMELCO 1	Samar I Electric Cooperative	10.2646	10.2646
SAMELCO 1 (SPUG)	Samar I Electric Cooperative		11.5958
SAMELCO 2	Samar II Electric Cooperative	9.8039	9.8039
SOLECO	Southern Leyte Electric Cooperative	9.2123	9.2123
SOLECO (SPUG)	Southern Leyte Electric Cooperative		10.9597

Source: kuryente.org.ph

In the Western Mindanao Region, the highest rate is charged by the Basilan Electric Cooperative (₱9.3179) and the lowest by the Zamboanga City Electric Cooperative (₱7.4712).

Table 11: Electricity rates in the Western Mindanao Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
WESTERN MINDANAO			
BASELCO	Basilan Electric Cooperative	9.3179	
CEPALCO	Cagayan Electric Power & Light Company	8.2360	8.3833
ZAMCELCO	Zamboanga City Electric Cooperative	7.4712	7.4712
ZAMSURECO 1	Zamboanga del Sur I Electric Cooperative	7.4929	7.4929
ZAMSURECO 2	Zamboanga del Sur II Electric Cooperative	8.1261	8.1261
ZANECO	Zamboanga del Norte Electric Cooperative	7.6220	7.622

Source: kuryente.org.ph

In the Northern Mindanao Region, the highest rate is charged by the Iligan Light & Power (₱13.4881) and the lowest by the Misamis Occidental Electric Cooperative II (₱7.5908).

Table 12: Electricity rates in the Northern Mindanao Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
NORTHERN MINDANAO			
BUSECO	Bukidnon II Electric Cooperative	9.8914	7.4188
CAMELCO, INC	Camiguin Electric Cooperative	11.3269	11.3269
FIBECO	First Bukidnon Electric Cooperative	10.1902	7.2052
ILPI	Iligan Light & Power	13.4881	6.747
LANECO	Lanao del Norte Electric Cooperative	9.7256	7.5953
MOELCI 1	Misamis Occidental I Electric Cooperative	8.6688	8.6688
MOELCI 2	Misamis Occidental II Electric Cooperative	7.5908	7.5908
MORESCO 1	Misamis Oriental I Rural Electric Coop	7.9431	7.9431
MORESCO 2	Misamis Oriental II Electric Service Coop	9.3880	9.388

Source: kuryente.org.ph

In the Southern Mindanao Region, the highest rate is charged by the Davao Oriental Electric Cooperative (₱8.7512) and the lowest by the Davao Light & Power Co. (₱7.5095).

Table 13: Electricity rates in the Southern Mindanao Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
SOUTHERN MINDANAO			
DANECO (SPUG)	Davao del Norte		10.911
DASURECO	Davao del Sur Electric Cooperative	8.0483	7.7078
DASURECO (SPUG)	Davao del Sur Electric Cooperative		8.6038
DLPC	Davao Light & Power Company	7.5095	7.4148
DORECO	Davao Oriental Electric Cooperative	8.7512	8.7512

Source: kuryente.org.ph

In the Central Mindanao Region, the highest rate is charged by the Cotabato Electric Cooperative (₱9.1046) and the lowest by the Sultan Kudarat Electric Cooperative (₱7.5892).

Table 14: Electricity rates in the Central Mindanao Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
CENTRAL MINDANAO			
COTELCO	Cotabato Electric Cooperative	9.1046	8.3344
SOCOTECO 1	South Cotabato I Electric Cooperative	8.5790	7.8431
SOCOTECO 2	South Cotabato II Electric Cooperative	8.8986	8.8986
SUKELCO	Sultan Kudarat Electric Cooperative	7.5892	7.3747
SUKELCO (SPUG1-LEBAK)	Sultan Kudarat Electric Cooperative		8.4687
SUKELCO (SPUG2-SNA)	Sultan Kudarat Electric Cooperative		8.4414
SUKELCO (SPUG3-PALIMBANG)	Sultan Kudarat Electric Cooperative		8.0337

Source: kuryente.org.ph

In Autonomous Region of Muslim Mindanao (ARMM), the highest rate is charged by the Tawi-tawi Electric Cooperative (₱9.7519) and the lowest by the Lanao del Sur Electric Cooperative (₱6.1825).

Table 15: Electricity rates in the Autonomous Region of Muslin Mindanao (ARMM), 2016

Acronym	Distribution Utility	2016 price	2014 price
ARMM			
CLPC	Cotabato Light & Power Company	6.4957	6.6297
LASURECO	Lanao del Sur Electric Cooperative	6.1825	6.1825
MAGELCO	Maguindanao Electric Cooperative	7.8239	7.8239
SIASELCO	Siasi Electric cooperative	8.9842	
SULECO	Sulu Electric Cooperative	8.2982	
TAWELCO	Tawi-tawi Electric Cooperative	9.7519	

Source: kuryente.org.ph

In CARAGA Region, the highest rate is charged by the Surigao del Sur Electric Cooperative II (₱11.2803) and the lowest by the Agusan del Norte Electric Cooperative (₱7.3862).

Table 16: Electricity rates in the CARAGA Region, 2016

Acronym	Distribution Utility	2016 price	2014 price
CARAGA			
ANECO	Agusan del Norte Electric Cooperative	7.3862	7.6173
ASELCO	Agusan del Sur Electric Cooperative	8.7551	8.7551
DIELCO	Dinagat Island Electric Cooperative	7.5532	
SIARELCO	Siargao Electric Cooperative	7.9879	7.5677
SURNECO	Surigao del Norte Electric Cooperative	8.9556	7.2571
SURSECO 1	Surigao del Sur I Electric Cooperative	8.6593	8.6593
SURSECO 2	Surigao del Sur II Electric Cooperative	11.2803	8.5263

Source: kuryente.org.ph

In summary, rooftop solar electricity is the cheapest source of electricity today (August 2016) in parts of the country where the retail price is more than ₱8.60/kWh. Since 106 of the 124 electric utilities for which 2016 information was available, or 85%, charged rates that were higher than the LCOE of rooftop solar, this means, that more or less, solar rooftops are already the consumer's cheapest source of electricity in more than 85% of the Philippines. In fact, the actual figure is probably more than 90%, because one of those 106 is the Manila Electric Company (Meralco), which provides more electricity than all the other electric utilities combined.

And it will even be better in subsequent years, as the next section will show.

Solar rooftops are already the consumer's cheapest source of electricity in more than 85% of the Philippines, and in an increasing number of other countries as well.

Chapter 2
Decreasing cost are inherent in solar panels

Solar rooftops are already the cheapest source of electricity today for more than 90% of electric utility customers. In the future, solar prices will decrease even further.

Why solar prices will keep going down

It is important to understand why decreasing costs is a feature of small systems like solar cells and panels (and silicon-based electronics, in general) but not of big systems like dams or coal plants.

Coal plants can be built 100 to 1,000 MW at a time. Dams can be built 10 to 100 MW at a time. Solar projects can be built with 100- to 250-watt panels at a time. Even a 1 MW solar power plant can consist of 4,000 250-watt panels.

To expand the country's generation capacity by 1,000 MW, we would need a 1–10 coal plants, or 10–100 dams, or 4–10 million solar panels. In fact, because of the lower capacity factor of solar panels, at least 20–50 million panels would be needed, to provide the same kWh output.

As the whole world makes the energy transition to renewables, particularly to solar electricity, several billion solar panels will eventually have to be manufactured *per year*.

Thus, solar technologies can benefit from the logic of learning curves and economies-of-scale in a way that is simply not possible when only ten or a hundred units need to be manufactured. Decreasing costs are *inherent* in the technology of solar PV.

This is why we can expect solar panel costs to continue their downward trend.

In the Philippines, for instance, the cost of solar panels in 1995 was around ₱129 per Wp.[8] By 2014, it had gone down to around ₱55 per Wp. Thus, over a 20-year period, the price went down by an average of 4.17% per year.[9] In 2016, it is around ₱50/Wp.

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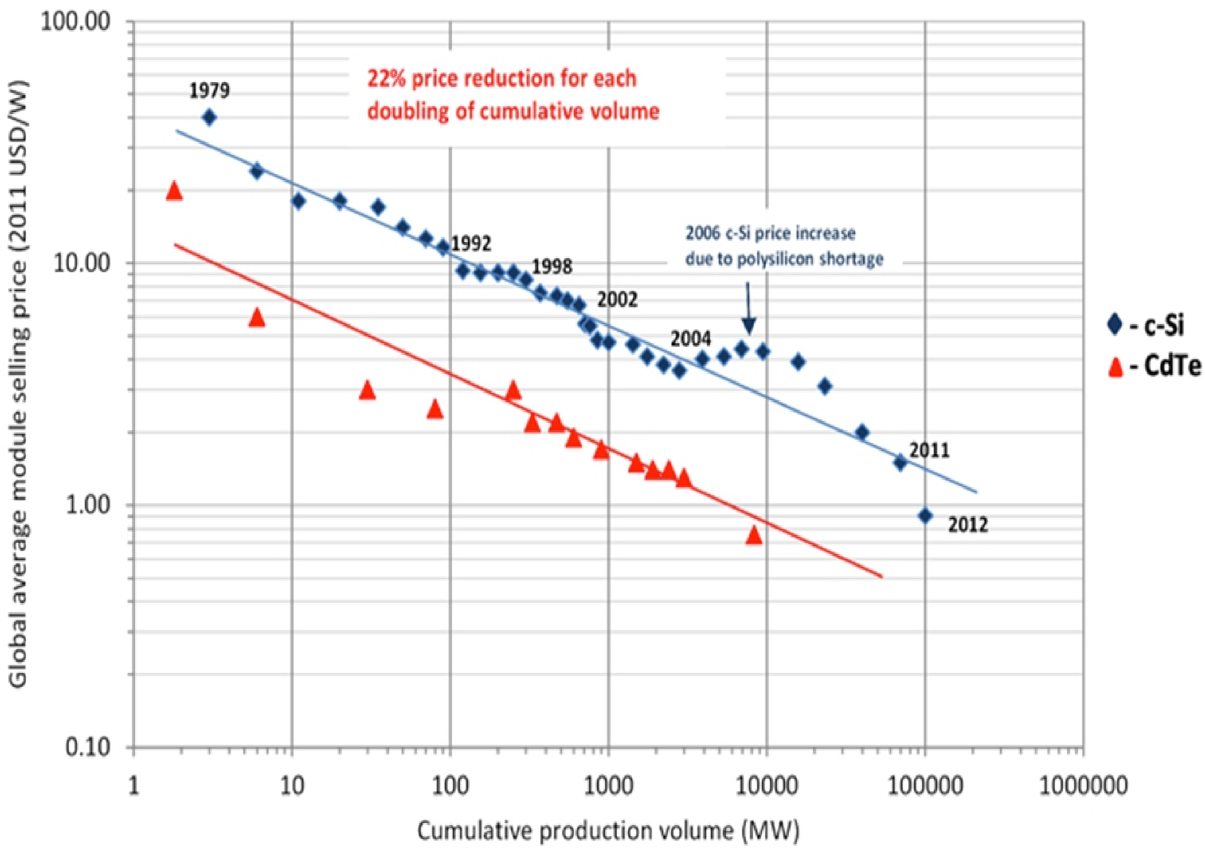
8 This figure is taken from Ferdinand Larona in "Community-Based PV Electrification Project: The Gregorio del Pilar Experience" as reported in the proceedings of the Regional Workshop on Solar Power Generation Using Photovoltaic Technology held in Manila (March 1996, p. 220).

9 $129 \times (1-0.0417)^{20} = 55$.

Just look at the following graph of global trends in the price of solar panels, which take up around half of the total cost of home PV systems.

Figure 2. Trend in Solar PV Panel Prices



Source: IRENA, "Renewable Energy Technologies: Cost Analysis Series Solar Photovoltaics," 2012, p.16

IRENA
International Renewable Energy Agency

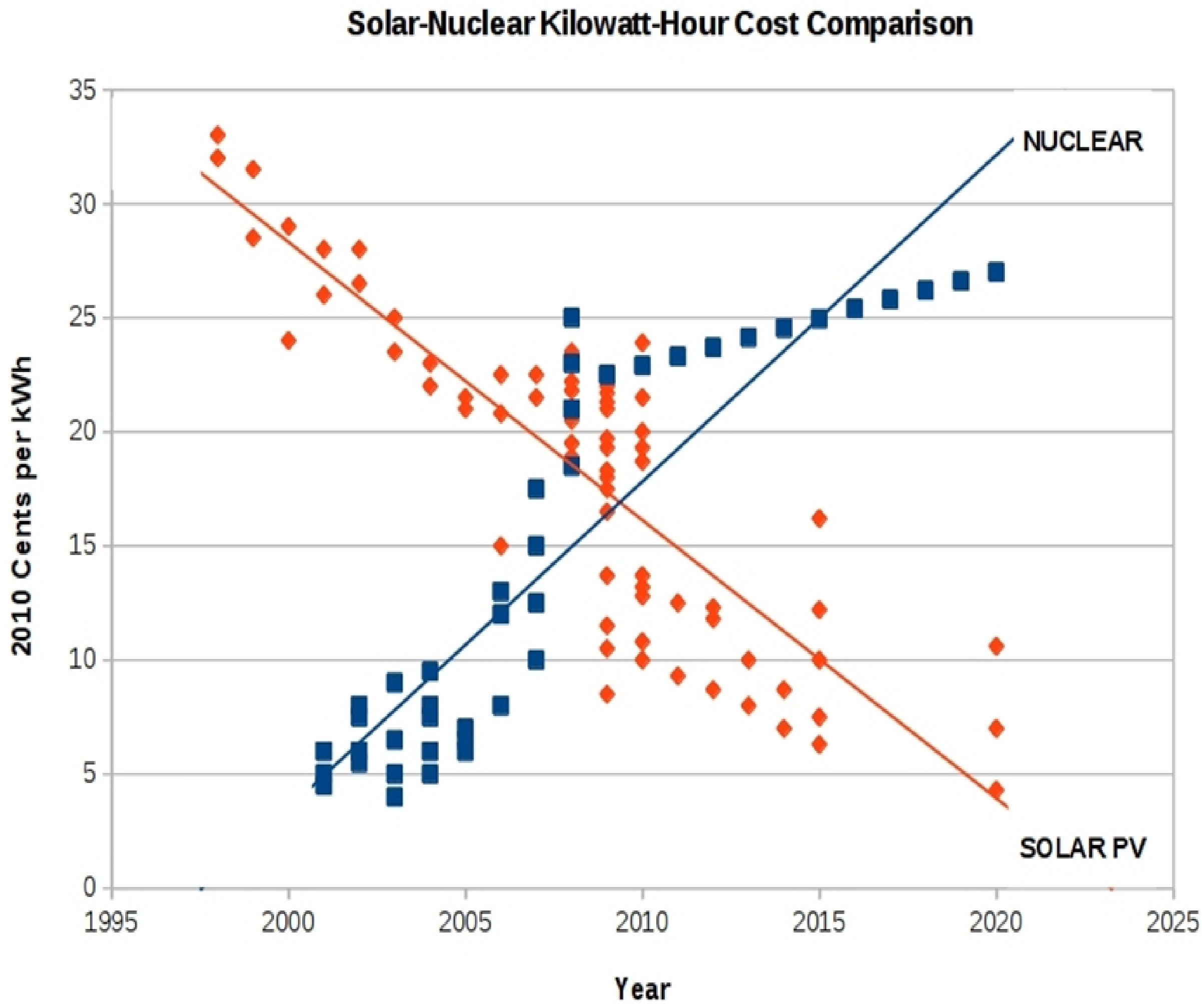
The upper trendline graphs the price of PV panels based on crystalline silicon while the lower trendline graphs the price of the cheaper but less efficient panels based on cadmium telluride (CdTe). The horizontal axis is the cumulative production volume of panels in megawatts, and the vertical axis is the price in dollars per Wp.[10]

Globally, the price of crystalline silicon was around US$9.00 in 1992, dropping to around US$1.50 in 2011, an average annual drop of 9.89% per year. Except for a slight increase in prices in 2006 due to a temporary shortage in silicon raw material, this steady downward trend has been observed consistently from 1979 to 2012. In 2014, crystalline silicon cost only around US$0.60 in the global market.

10 Note that the scales are logarithmic. Logarithmic scales exaggerate lengths/distances for very small numbers and compress lengths/distances for very large numbers.

The next graph shows the trendline of solar electricity costs in the US, compared to the trendline of nuclear electricity costs, showing that the cross-over point between the two costs occurred sometime in 2010, when solar became cheaper than nuclear.[11]

Figure 3. Solar-Nuclear Kilowatt-hour Cost Comparison



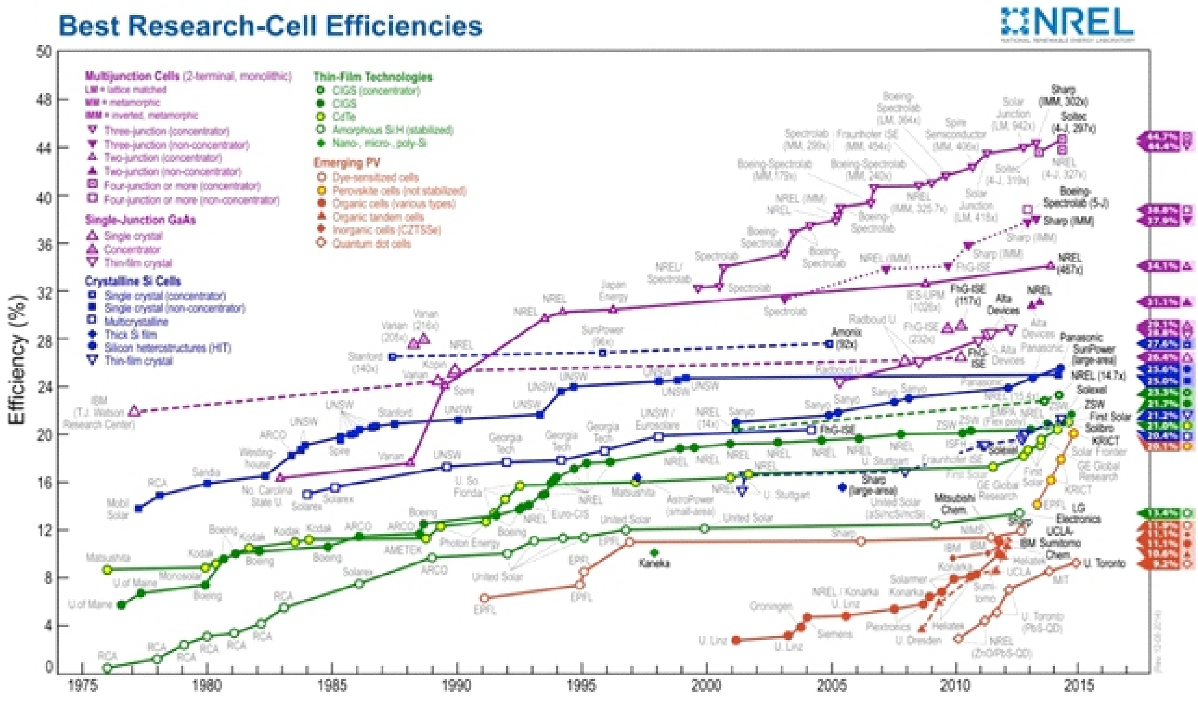
Source: Blackburn and Cunningham, 2010 (graph redrawn by author to improve resolution)

And as more of them are made, the cost of research and development (R&D) can then be spread out over the billions of panels that will be made, making it easier to justify and conduct solar R&D. As a result, we can expect more technological improvements in the future, which promise more rounds of price reductions.

Consider the next figure, which graphs the major R&D advances in various solar research laboratories throughout the world. The highest cell efficiency attained in the lab so far is 44.7%. Compare this to the 15-16% efficiencies of solar modules on the market and it is clear that we can expect even cheaper solar panels in the future, which can produce higher outputs for the same area.

11 The solar-nuclear cross-over point had occurred much earlier, if the health, social and environmental costs of nuclear power and nuclear wastes were fully taken into account.

Figure 4. Solar R&D continues to raise panel efficiencies attained in the lab



Source: http://www.nrel.gov/ncpv/images/efficiency_chart.jpg
(U.S. National Renewable Energy Laboratory)

Auctions and biddings are often held in various countries where companies propose to build a solar farm that can supply electricity at a contracted price that they guarantee as part of their bid. The year 2016 saw further dramatic reductions in the price of solar electricity, as summarized in the following table:

Table 17: Winning bids for solar electricity supply contracts, 2016.

Location	Bidders	Size (MW)	COST (US¢/kWh	Month (2016)
Peru	Enersur	185	4.80	Feb
Palo Alto, U.S.	Hecate Energy		3.68	Feb
Mexico	Enel Green Power		3.55	Mar
DUBAI	ALJ+FRV+Masdar	200	2.99	May
Chile	Solarpack		2.91	Aug
Abu dhabi	Marubeni+JinkoSolar	300	2.42	Sep

Source: Compiled by the author from various industry reports

We estimated in the first edition of this book an average drop of 9% per year over the past several decades. In comparison, the above table essentially shows a 50% drop in price over seven months, or about 9.3% *per month*. The September 2016 price of 2.42 US¢ is around ₱1.16/kWh—far lower than what can be attained with any other existing technology, renewable or non-renewable, except for energy efficiency measures. Contractors claim that the LCOE for solar farms is about 60% lower than for rooftop solar. This would still put the rooftop solar LCOE at ₱1.94/kWh. If we can bring these prices to the Philippines, where the current grid price hovers around ₱9.00/kWh, the rules of the game will change completely, especially since we can expect solar prices to continue to decline.

In this book's first edition, we wrote that generating electricity from wind turbines and hydroelectric installations today is still cheaper than getting it from solar panels. Apparently, not anymore—that is how fast things are changing. Also, these two technologies do not enjoy the same economies of scale and learning curves in manufacturing that the latter does. In addition, it is not practical to install wind and hydro power in every household. Thus, unlike solar, these two other forms of renewable power have to take into account the economics of transmission and distribution.

Increasing prices of non-renewables

On the other hand, we can expect the prices of coal, oil and other fossil fuels to keep increasing in the long term, as the world gradually uses up these non-renewable fuels. In the short and medium terms, these resources will be subject to unpredictable ups and downs, as the following medium-term assessment by the International Energy Association shows:[12]

> "Global demand for coal over the next five years will continue marching higher, breaking the 9-billion-tonne level by 2019, according to Medium-Term Coal Market Report 2014. The report notes that despite China's efforts to moderate its coal consumption, it will still account for three-fifths of demand growth during the outlook period. Moreover, China will be joined by India, ASEAN countries and other countries in Asia as the main engines of growth in coal consumption, offsetting declines in Europe and the United States.
>
> "Global coal demand growth has been slowing in recent years, and the report sees that trend continuing. Coal demand will grow at an average rate of 2.1% per year through 2019, the report said. This compares to the 2013 report's forecast of 2.3% for the five years through 2018 and the actual growth rate of 3.3% per year between 2010 and 2013.
>
> "As has been the case for more than a decade, the fate of the global coal market will be determined by China. The world's biggest coal user, producer and importer has embarked on a campaign to diversify its energy supply and reduce its energy intensity, and the resulting increase in gas, nuclear and renewables will be staggering. However, the IEA report shows that despite these efforts, and under normal macroeconomic circumstances, Chinese coal consumption will not peak during the five-year outlook period.
>
> "Medium-Term Coal Market Report 2014's forecasts come with considerable uncertainties, especially regarding the prospect of new policies affecting coal. Authorities in China as well as in key markets like Indonesia, Korea, Germany and India, have announced policy changes that could sharply affect coal market fundamentals. The possibility of these policy changes becoming reality is compounding uncertainty resulting from the current economic climate."

Thus, rooftop solar is going to be cheaper than coal and other non-renewables by an increasingly larger margin, *without government subsidy*.

What about the hidden cost of non-renewables?

If coal- and oil-based generating plants had to reflect in their prices the health, environmental and social costs of using them—as they should—wind and hydro will also be

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12 "Medium-Term Reports," International Energy Agency, (Accessed January 29, 2015), http://www.iea.org/publications/medium-termreports/#d.en.27705.

cheaper sources of electricity than fossil fuels. Under current policy regimes where these externalities are ignored, representing huge hidden subsidies for fossil fuels, wind and hydro may need some external support themselves, to make them more competitive to coal while attracting more investors. The viability of wind projects will be further explored in subsequent chapters.

In general, given the same extent of support that fossil fuels are unfairly enjoying today, these three major sources of renewable energy can already be considered financially viable today. And if transmission and distribution costs were taken into account, rooftop solar is now cheaper than all other non-renewable technologies because it does not incur these additional costs.

We can therefore argue that *no* new fossil- or nuclear-fueled generating plants should anymore be initiated today, because this will lock us into technologies which are not only expensive today, but will be even more so in the future. On the other hand, renewables are already cheap today (cheaper than the rest, in case of rooftop solar) and will be even more so in the future.

Coal plants take around five years to build (nuclear plants take ten or more years). Once they start operations, their fuel prices will keep getting more expensive over the years, while renewables will keep getting cheaper and cheaper.

To allow ourselves to be locked-in today to highly polluting, imported and soon-to-be expensive non-renewables will be sheer madness.

If this is the case, then why are we not yet sourcing all of our electricity from renewables? And what can we do to hasten the energy transition to 100% renewables?

These are the questions this study will try to answer.

But before we answer these questions, let us first convince ourselves that 100% renewable electricity is possible in the Philippines. This is what the next section will do.

Chapter 3

Renewable electricity: is there enough?

In 2015, the most recent year for which national data is available, the Philippines consumed a total of 82,413 GWh of electricity,[13] with an average annual increase over the ten-year 2006–2015 period of 4.2% per year. The historical trend can be seen in Table 18.[14]

Table 18. Philippine Power Statistics, 2006-2015

Year	Consumption (GWh)	Non-renewable portion	Year	Consumption (GWh)	Non-renewable portion
2006	56,784	36,325	2011	69,176	49,331
2007	59,612	40,774	2012	72,922	52,161
2008	60,821	40,193	2013	75,266	55,363
2009	61,934	41,744	2014	77,261	57,452
2010	67,743	49,920	2015	82,413	61,450

Source: DOE, 2016

The table above also gives us the amount of non-renewable electricity that we must replace with renewables to attain 100% renewability in the electricity sector in 2015: *61,450 GWh*.

To imagine 100% RE in the electricity sector in 2015, we must replace 61,450 GWh of non-renewables.

13 This figure excludes system losses and electricity produced by generating plants for their own use.

14 "Philippine Power Statistics 2015," Department of Energy, (Accessed August 29, 20165), https://www.doe.gov.ph/ doe_files/pdf/02_Energy_Statistics/Power-Statistics-2015.pdf.

Solar electricity

The earth's surface receives around 1,000 watts (1 kilowatt, or 1 kW) of solar irradiance per square-meter at sea level when the sun is directly overhead.[15]

In 2015, the most efficient photovoltaic panels could convert up to 44% of sunlight into electricity, and even better conversion efficiencies are expected in the future. The typical solar photovoltaic (PV) panels sold in the Philippines could convert sunlight at an efficiency of around 15%. From each square-meter of solar panel, therefore, we can get today around 0.15 kW of direct current electricity.

When the sun rises in the morning, the available sunshine becomes gradually more intense, reaching its peak around midday. Each hour which the sun spends when it is directly above, on cloudless days, is called a "peak sun hour." We will use "peak sun hour" and "peak-hour" interchangeably. Past the sun's highest point, the available sunshine becomes gradually less intense until it flattens after sunset.

The output power (in watts) specified for a solar panel is measured under sunlight when the sun is at its peak, on cloudless days. That is why the capacity of a solar panel is specified in watts-peak (Wp).

In one peak sun hour, a one-kWp solar array produces one kWh of electricity.

If daylight lasts for twelve hours, even on cloudless days, a one-kWp solar array may produce not twelve but only six kWh of electricity, because of the variation in solar intensity from dawn to dusk. Thus, the three hours from 6 to 9 am might be the equivalent of only one peak-hour. The two hours from 9 to 11 am might be another peak-hour. Then, 11am to 12 noon would be a full peak-hour. Again, after midday, 12 to 1 pm might be a full peak-hour, 1 to 3 pm another peak-hour, and 3 to 6 pm a final peak-hour, for a total of only six peak-hours. Several hours of early morning hours, cloudy midday hours, late afternoon hours need to be accumulated to get the same output as one peak-hour. On cloudy days, the one-kWp solar array may produce in one whole day 3 kWh only. Such a day is said to consist of three peak-hours.

Thus, peak-hours are the measure of a location's average intensity of sunlight. The technical term is "incident solar radiation", or insolation.

Solar PV output, costs

The Philippines gets 3.5 to 5.5 peak-hours of sunlight per day.[16] This means that a square meter of solar panel will produce from 0.525 to 0.825 kWh of household electricity per day. Let us use the average of 0.675 kWh per day or 20.25 kWh per month. If we assume a system efficiency of 85% in converting around 18 volts DC from the solar panel to the 220-volt AC that emulates the grid electricity from our home outlets, then the output of the same square-meter of panel goes further down to an average of 17.2 kWh per month per square meter.

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15 Neville Williams, *Sun Power: How Energy from the Sun is Changing Lives Around the World, Empowering America, and Saving the Planet* (New York: Tom Doherty Associates, 2014), p. 345.

16 The DOE says "4.5 to 5.5" peak-hours (see DOE, "Large Solar Photovoltaic Project Development in the Philippines). A USAID document says "3.5 to 5.2" (see USAID, "Harnessing Solar Energy for Off-grid Rural Electrification").

In the Philippines, the price of the simplest solar PV system (solar panels plus grid-tie inverter, no battery) in 2016 ranged from ₱90.00 to ₱110.00 per Wp. Henceforth, we will use the average of ₱100.00 per Wp, or ₱100,000 per kWp (we used ₱110,000 in the first edition).

Let us turn the above figures into a table of solar conversion factors, to facilitate quick calculations:

Table 19. Solar PV System Conversion Factors

	= square-meters (m^2)	= kWp	= kWh/month	= thousand pesos
square-meters (m^2)		x 0.15	x 17.2	x 15
kWpk	÷ 0.15		x 115	x 100
Wh/mo	÷ 17.2	÷ 115		÷ 1.15
thousand pesos	÷ 15	÷ 100	x 1.15	

Source: Author's calculations.

The table above helps us convert from the units in left-most column to the units in the top-most row. Their intersection is the conversion factor.

Let us say that our electricity consumption is 170 kWh per month and we want to know how much kWp of solar panels to buy to cover this level of consumption: the conversion factor from kWh/mo. to kWp is "÷ 115". Thus, 170 ÷ 115 = 1.478. We need around 1.5 kWp of solar panels. This means a solar array of fifteen 100-Wp panels, or ten 150-Wp panels, or six 250-Wp panels, or five 300-Wp panels. There are no 500-Wp panels yet in the Philippine market.

To determine how much a complete system of 1.5 kWp panels will cost, we can see from the table that the conversion factor from kWp to thousand pesos is 100. Thus 1.5 kWp x 100 = 150 thousand pesos or ₱150,000.

Another example: suppose you inherit ₱300,000.00 from a rich uncle and would like to know how much PV system this amount can buy. The conversion factor from a thousand pesos to kWp is "÷ 100". Since 300 ÷ 100 = 3 kWp, this means you can afford to buy a 3 kWp PV system. The conversion factor from kWp to kWh/mo is x 115. Thus, 3 x 115 = 345 kWh/mo. This is the average monthly production you can get out of the PV system you can buy for ₱300,000.00.

Just 1% of the country's land area can generate nearly 14 times the 61,450 GWh we generated from non-renewables in 2015.

Let us return to our target of 61,450 GWh per year, which is equivalent to 61.5 billion kWh per year or 5,121 million kWh per month. The conversion factor from Kwh/mo to m^2 is ÷ 17.2. Therefore, we need 298 million m^2 (29,800 ha) of PV panels to generate all the electricity which we estimated above would let us attain 100% renewable electricity in 2015 (5,121 million ÷ 17.2 = 298 million).

The Philippines covers a land area of 30 million ha. Just 1% of this area means 300,000 ha, which is ten times the 29,800 ha required to become fully renewable in electricity in 2015. Even just one-tenth of 1%, or 30,000 ha, is still enough area needed to phase out all fossil-fuel-based electricity in 2015.

We have assumed that the financial resources exist and enough storage facilities are available to store excess production, which could then be released when there is little or no sunlight. These are obviously huge assumptions. But we are only trying to establish at this point whether we have the physical resources for a full energy transition to renewable electricity. So let us suspend our disbelief for a moment and continue what we might call a thought experiment.

The Philippines has 1,633 cities and municipalities (we will use the term "towns" for both). If we distribute among these the 29,800 ha required for an energy transition to 100% renewable electricity, then each town needs to put up 18.2 ha of solar panels. Around 6.1 ha per town will take us one-third of the way. Another 6.1 ha will take us two-thirds of the way. Still another will be more than enough to make the full transition.

Temporarily setting aside at this point the little details that the devil can throw against us, we can easily imagine meeting our entire electricity consumption *from solar power alone*, if the money and the right storage facilities were available.

Wind electricity

We will use the following conversion table for wind turbines.

Table 20. Wind Turbine Conversion Factors

	= MW, rated	= MWh/yr	= million pesos
MW, rated		x 2,575	x 119.5
MWh/yr [17]	÷ 2,575		÷ 21.55
million pesos [18]	÷ 119.5	x 21.55	

Source: Author's calculations.

According to a 2000 NREL study on wind energy resource development in the Philippines, based on a conservative estimate that excludes areas with average wind speeds lower than 6.4 m/sec:

> "The total wind electric potential from areas with good to excellent wind resource is conservatively estimated to be 76,000 megawatts of installed capacity or approximately 195 billion kilowatt hours per year."

17 Based on an assumed wind turbine capacity factor of 30% and electrical system efficiency of 98%.

18 Based on the TAREC investment of ₱6.453 billion for 54 MW of wind turbines.

The study summarizes the country's wind resources in Table 21 (below).

The NREL figure of 195 billion kWh wind electricity potential is equivalent to 195,000 GWh. This is more than three times the indicative target of 61,450 GWh we need to attain 100% RE in 2015. Nearly six times our target, if we include the areas with moderate potential, which raises the total potential to 361,000 GWh. These figures already take into account the inherent variability of the resource.

Table 21. Potential Electricity Output from Wind Energy in the Philippines

Wind Resource Utility Scale	Wind Power W/m²	Wind Speed m/s	Total Area km²	Total Capacity Installed MW	Total Power GWh/yr
1. Moderate	200–300	5.6–6.4	14,002	97,000	165,800
2. Good	300–400	6.4–7.0	5,541	38,400	85,400
3. Excellent	400–600	7.0–8.0	4,304	29,800	82,400
4. Excellent	600–800	8.0–8.8	1,112	7,700	25,100
5. Excellent	800–1200	8.8–10.1	98	700	2,300
Total (#2-5)			11,055	76,600	195,200
Total (#1-5)			25,057	173,600	361,000

Source: Elliott, 2000.

Based on these conservative estimates, 25 provinces have at least 1,000 MW wind electric potential, and 22 more have 500–1,000 MW wind electric potential. The rest have a potential below 500 MW. If areas with average wind speeds of 5.6–6.4 m/sec were included (good for rural applications and non-commercial electric generation), 51 provinces will have at least 1,000 MW wind electric potential, and 13 more will have 500–1,000 MW wind electric potential.[19]

The country's wind potential is 12 times the 61,450 GWh of the electrical energy we need to generate to be 100% renewable.

The study divided the country, for the purpose of regional wind resource mapping, into 13 regions: 1) Batanes and Babuyan Islands; 2) Northern Luzon; 3) Central Luzon; 4) Mindoro, Romblon, Marinduque, and Southern Luzon; 5) Southeastern Luzon, Masbate and Catanduanes (Bicol Region); 6) Samar and Leyte; 7) Panay, Negros, Cebu and Siquijor; 8) Bohol and Northern Mindanao; 9) Southern Mindanao; 10) Western Mindanao and Basilan; 11) Northern Palawan; 12) Southern Palawan; and 13) Basilan, Sulu and Tawi-Tawi. Each region is covered by a detailed wind resource map.

19 Dennis Elliott, et al., “Philippines Wind Energy Resource Atlas of the Philippines,” p. 87.

The above study is based on a 30-meter turbine height, and has been updated by a more recent NREL study (March 2014). The 2014 study takes into account larger-sized and 80–100 meter-high turbines, enabling wind turbines to harvest more than four times the energy potential estimated in the earlier study. Our total wind potential then turns out to be more than 12 times what we need to go fully renewable.

This shows that the wind electric potential available to the country is far more than enough to attain a 100% RE goal *from wind power alone*, if we had the right storage facilities.

Micro-/Mini-hydro

The next table gives the conversion factors for mini- and micro-hydro installations.

The 47% capacity factor used in the table is the most commonly cited average capacity factor for hydroelectric plants in the Philippines. In the previous edition, we used 32%, calculated from the 2013 hydroelectric data of the DOE, which is quite low and therefore tends to understate the production potential of hydroelectric plants and to overstate its levelized cost of electricity. The low capacity factor is probably due to the low rainfall that year, and is not inherent in the technology. Even the 47% figure is based on ageing hydroelectric plants, some of whose dams are already heavily silted.

So, remember that the conversion factors given in the table are highly sensitive to variations in the capacity factor.

Table 22. Mini-and-Micro-hydro Conversion Factors

	= MW, rated	= MWh/yr	= million pesos
MW, rated		x 4,117	x 140
MWh/yr [20]	÷ 4,117		÷ 29.4
million pesos [21]	÷ 140	x 29.4	

Source: Author's calculations.

According to the DOE, the country's potential from its micro-hydro resources is 27 MW and 1,847 MW from mini-hydro. We are excluding for the moment large hydro as well as geothermal installations to skirt the debates on their social and environmental impacts.

If we apply the same capacity factor of 47% to these micro- and mini-installations, we would be able to generate from these resources around 7.7 billion KWh or 7,700 GWh per year, good enough to replace slightly more than 12% of our national consumption of non-renewable electricity in 2015.

We have enough hydroelectric resources still untapped to replace 77% of the non-renewable electricity we have produced in 2015.

20 0.47 x 24 x 365 = 4,117.

21 Based on 2.5 million euros/MW at ₱56.00/euro.

Of course, if we included the country's large untapped hydro potential of 10,500 MW (43,200 GWh per year at 47% capacity factor) into the equation, we would be able to replace another 70% of our entire consumption of electricity from non-renewable resources in 2015, for a total of 82%, *from hydro alone*.

Assuming a geothermal plant capacity factor of 60%, our untapped geothermal potential of about 1,200 MW is good for around 6,300 GWh per year, or 14% of our non-renewable electricity consumption.[22]

Mixing the flexible output from hydro, the steady output from geothermal resources, and the intrinsically variable output of solar and wind resources can provide more stability for the electricity grid.

In this section, we answered the question: Do we have enough physical resources in the country to make the full transition to renewable electricity? Clearly, the answer is yes.

In the next section, we will answer the question: Can we rely on renewables only for all future additions to our generating capacity?

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22 The average capacity factors of 32% for hydro and 60% for geothermal were calculated by the author from 2013 MW capacity and GWh output statistics released by the DOE, using the formula CF = 1000 * Output (GWh) ÷ [capacity (MW) × 24 × 365].

Chapter 4
100 % renewable: how soon?

The previous chapter showed that the Philippines has enough resources to generate all of its electricity from renewable resources.

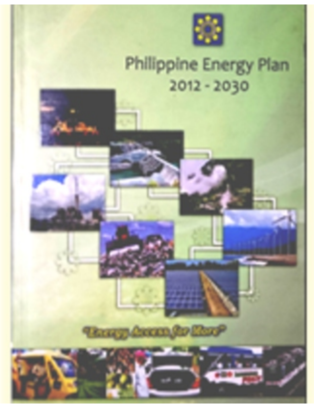
This chapter will show that if we focus on new demand and supply only, taking as given the existing and committed power plants, the shift to 100% renewables can occur sooner than most people think.

The Philippine Energy Plan 2012-2030: a remarkable document

This chapter is a historical case study of the energy plan of the Aquino administration. Hopefully, the Duterte administration can learn from the good and bad points of the Aquino energy plan.

We will show that it was already possible for the Philippines to attain a 100% renewable future (i.e., for new demand and supply only) as early as 2013, because the programs needed to attain this goal were already in the Aquino administration's Philippine Energy Plan 2012-2030 (PEP 2012, for short).

Figure 5. The remarkable PEP 2012-30



PEP 2012 (Figure 5) was published by the Department of Energy as the official energy plan of the Philippine government.

Had the government taken seriously the specific targets of two PEP 2012 components—the Philippine Energy Efficiency Project (PEEP) and the National Renewable Energy Program (NREP)—this paper will show that the country would have been able within a short period to meet all new electricity demand with 100% renewable energy.

This, in turn, would have removed the need for any fossil-fueled power plant in the country's energy plans for the future.

Unfortunately, the combined impact of the PEEP and the NREP were not seen in this light by the Philippine government. No energy official apparently made the connection nor saw the synergy. Thus the remarkable conclusions lurking within the PEP 2012 have remained hidden and unappreciated until now.

Energy-efficient demand, 100% renewable new supply

We will establish our conclusions above by using the following government numbers and targets given in the PEP 2012:

A. *Lower, more energy-efficient demand projections, 2012-30***.** Given the PEP 2012 business-as-usual demand projections, we will apply the PEEP target to generate new demand projections, which will be lower because they are more energy-efficient.

B. *New required reserves, 2012-30***.** From these new demand projections, we will use the government's own formula to calculate the required reserves.

C. *New required supply capacity, 2012-30***.** The energy-efficient demand projections plus the required reserves will give the required supply for the planning period.

D. *Baseline capacity as of 2011***.** The dependable installed capacity plus committed projects as of 2011 will give the baseline capacity as of 2011.

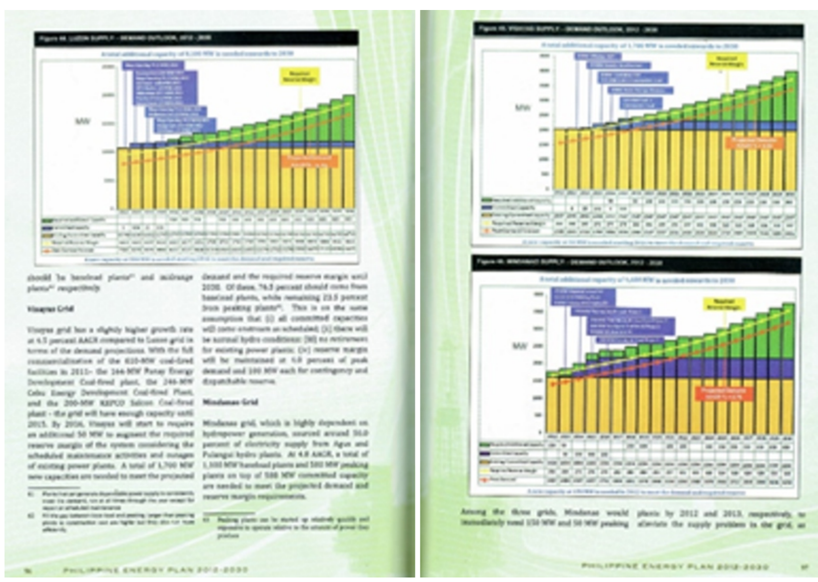
E. *New required supply capacity additions, 2012-2030*. The required supply minus this baseline capacity gives the new additions that the government must actually plan for.

F. *Planned RE-only additions, 2012-30***.** The National Renewable Energy Plan contains the planned RE additions. If the total of these additions exceeds the required new supply, then it becomes possible for new supply to come from RE-only plants. This means we can exclude fossil-fueled power plants from our energy planning for the future. No more coal in future energy plans.

Now, the details.

A. New, energy-efficient demand projections: BAU projections minus PEEP targets

PEP 2012 gives a "reference scenario," its projection of the country's business-as-usual (BAU) electricity demand for the specified period. This scenario projects an expected BAU demand of 23,158 MW by the end of the planning period in 2030. (For the numbers, see Table 23, second column)



Source: Department of Energy, PEP 2012-30, Figs. 44-46, pp.96-97

The Philippine Energy Efficiency Project, or PEEP (PEP 2012, 144-149), trims down the growth of electricity demand. The PEEP target is 200 MW savings per year (PEP 2012, 144). The project intends to attain this mostly by distributing CFLs to the residential sector. Assuming that the project has been attaining its goal since 2013 and would continue to do so until 2030, then this would reduce the government's BAU demand projections by 200 MW per year, to arrive at an energy-efficient demand growth scenario for the Philippine power sector (Table 23, third column).

Table 23. Philippine demand and supply scenarios, 2012-2030, MW

Demand and Supply Scenarios, MW				
	Demand Scenario		**Required Supply**	
Year	**BAU**	**Efficient**	**BAU**	**Efficient**
2012	10,944	10,944	12,676	12,676
2013	11,402	11,202	13,152	12,944
2014	11,865	11,465	13,634	13,218
2015	12,348	12,748	14,136	13,512
2016	12,832	12,032	14,639	13,807
2017	13,352	12,352	15,180	14,140
2018	13,880	12,680	15,729	14,481
2019	14,429	13,029	16,300	14,844
2020	14,998	13,398	16,892	15,228
2021	15,660	13,860	17,580	15,708
2022	16,353	14,353	18,301	16,221
2023	17,076	14,876	19,053	16,765
2024	17,834	15,434	19,841	17,345
2025	18,625	16,025	20,664	17,960
2026	19,453	16,653	21,525	18,613
2027	20,319	17,319	22,426	19,306
2028	21,223	18,023	23,366	20,038
2029	22,169	18,769	24,350	20,814
2030	23,158	19,558	25,378	21,634

Source: Author's calculations, based on government figures and formulas

Note that while the BAU scenario shows a year-on-year increase averaging 4.25%, the energy-efficient scenario averages only 3.28%, clipping nearly 1% from the projected average annual growth rate in electricity demand.

B. New required reserves: 4% of demand plus 1,294 MW

It is not enough to supply as much electricity as the demand for it.

Based on Philippine electricity regulations on grid reliability, the government requires each grid to maintain a supply capacity that is higher than the demand by the following amounts: a frequency regulation reserve (FRR) of 4% above the demand; a contingency reserve (CR) equal to the size of the most heavily loaded generator (647 MW for Luzon, 100 MW for the Visayas, and 105 MW for Mindanao); and a dispatchable reserve (DR) of the same amount as the CR (PEP 2012, 98). We will use the Luzon figure in this study.

C. New required supply capacity: projected demand plus required reserves

Adding the 4% FRR, plus the 647 MW DR and another 647 MW CR gives us our new supply targets for the period 2012-2030 under an energy-efficient growth scenario (Table 23, last column). The final supply target by 2030 is 21,634 MW during peak demand.

D. Baseline supply: existing dependable capacity plus committed capacity

The next important piece of information that we will take from PEP 2012 is the amount of installed capacity (in MW) as of the start of the planning period (see Table 24).

Conservatively, we will be using not the 16,266.9 MW of installed capacity as of 2011, but only the 14.477.04 MW which were considered "dependable". Of these dependable capacity, 4,477.54 MW (30.93%) were renewable, while 9,999.5 MW (69.07%) were fossil-based. This mix of existing RE and non-RE power plants will be taken as given.

Table 24. Installed and Dependable Capacity in MW, 2011

Philippines				
Plant Type	**Capacity (MW)**		**Percentage Share%**	
	Installed	Dependable	Installed	Dependable
Coal	4,916.60	4,650.80	30.42	32.13
Oil Based	2,994.11	2,578.70	18.53	17.81
Natural Gas	2,861.00	2,770.00	17.70	19.13
Geothermal	1,847.69	1,433.87	11.03	9.90
Hydro	3,490.73	2,963.47	21.60	20.47
Wind	33.00	33.00	0.20	0.23
Solar	1.00	1.00	0.01	0.01
Biomass	72.76	46.20	0.51	0.32
Total	**16,226.90**	**14,477.04**		

Source: PEP 2012-2030, p.86

In addition to these existing plants, PEP 2012 lists some 19 proposed projects that had earlier been initiated and were already under construction. As of 2011 (Table 25), these committed projects had a total capacity of 1,766.7 MW, of which 210.7 MW (11.89%) were renewable and 1,556.0 MW (88.11%) were fossil-based, mostly coal.

Together, this dependable capacity (14,477.04 MW, 30.93% RE) plus the committed projects (1,766.7 MW, 11.93% RE) comprise our baseline supply—the supply capacity we will take as given. This total baseline supply is 16,243.74 MW (28.86% RE).

E. New required supply additions: required supply minus baseline supply

The required supply (C: 21,634 MW) minus the baseline supply (D: 16,244 MW) gives the new additions that the government must actually plan for: 5,390 MW. Under the country's Electric Power Industry Reform Act (EPIRA) of 2001, the government can only do so, not by building power plants itself, but by creating favorable conditions to encourage the private sector to do so.

Table 25. Committed Power Projects, as of 2011

	Sub-total Luzon	**868.70**			
Visayas	2x135-MW Concepcion Coal Fired Power Plant	270.00	Unit 1 3Q 2014 Unit 2 Sep 2015	Concepcion, Iloilo	Palm Thermal Consolidated Holdings Corp.
	Nasulo Geothermal Plant	20.00	December 2013	Nasuji, Valencia, Negros Oriental	Energy Development Corporation
	Villasiga HEP*	8.00	December 2012	Sibalom, Antique	Sunwest Water & Electric Co. Inc.
	Cantakoy HEP*	8.00	Q4 2014	Danao, Bohol	Cantakoy Hydroelectric Power project
	Asian Energy System Biomass Project*	4.00	December 2015	Cebu	Asian Energy System Corp.
	Sub-total Visayas	**310.00**			
Mindanao	2x4-MW Cabulig Mini Hydro Power Plant*	8.00	Operational	Jasaan, Misamis Oriental	Mindanao Energy System, Inc.
	15-MW Diesel Power Plant	15.00	2013	Iligan City	Mapalad Energy Generating Corporation
	15-MW HFO Peaking Plant	15.00	Q4 2012	Tagum City, Davao del Norte	EEI Power Corporation
	2x150-MW Coal-Fired Therma South Energy Project	300.00	2014	Sta. Cruz, Davao del Sur	Therma South Inc.
	Mindanao 3 Geothermal	50.00	2014	Kidapawan, North Cotabato	Energy Development Corporation
	2x100-MW Southern Mindanao Coal	200.00	2014	Maasin, Saranggani	Saranggani Energy Corporation
	Sub-total Mindanao	**588.00**			
	Total	**1,766.70**			

Source: DOE, PEP 2012-30, p.94

F. The government's planned RE additions

Let us now look at the government's renewable energy program to see whether it is sufficient to meet the new supply capacity that must be added.

Table 26. The government's planned RE additions, 2012-2030, MW

Table 87. Summary of RE Investment Requirements

Renewable Energy Resources	Capacity (MW)	Investment Requirements (Million PhP)
Hydropower*	4,752.94	598,870.44
Biomass	52.40	8,695.67
Geothermal*	1,165.00	2,346.21
Wind*	1,915.00	1,561.26
Ocean*	70.50	493.50
Solar*	284.05	134.69
Total	**8,239.89**	**612,101.77**

The National Renewable Energy Program (NREP) has set aggressive targets for capacities to be generated utilizing various renewable energy (RE) resources in the country. As indicated in Table 87, PhP 612.10 billion will be needed for the development of RE resources to provide an additional estimated capacity of 8,240 MW over the entire planning period. The preparatory activities for the development of hydro projects comprise 98% of the total RE investment cost at PhP 598.87 billion. Further PhP 8.70 billion will be required for biomass projects, PhP 2.35 billion for geothermal

Source: PEP 2012, p.164.

* Pre-Development Cost

The planned RE additions under the government's National Renewable Energy Program (NREP) will reach 8,240 MW by 2030, broken down in Table 26 above (PEP 2012, 164).

The government's RE-only program already exceeds the new required supply additions of 5,390 MW. Even if we excluded, for the sake of argument, the variable (solar and wind) and the experimental (ocean), this still leaves 5,970 MW, more than enough—with 580 MW to spare—to cover the required supply additions for the planning period. These would have come mostly from hydro and geothermal.

While PEP 2012 provides RE targets for the final year of the planning period, the full details of the government's RE program are provided in a separate official document, the electronic version (in PDF) of which is identified as the "NREP Book" and posted at the Department of Energy website. The NREP Book breaks down the government's 2011-2030 RE targets into five-year intervals. (Table 27)

Table 27. The government's planned RE additions, 2012-2030, MW

Sector	Installed Capacity, (MW) as of 2010	Target Capacity Addition by				Total Capacity Addition (MW) 2011-2030	Total Installed Capacity by 2030
		2015	2020	2025	2030		
Geothermal	1,996.0	220.0	1,100.0	95.0	80.0	1,495.0	3,461.0
Hydro	3,400.0	341.3	3,161.0	1,891.8	0.0	5,394.1	8,724.1
Biomass	39.0	276.7	0.0	0.0	0.0	276.7	315.7
Wind	33.0	1,048.0	855.0	442.0	0.0	2,345.9	2,378.0
Solar	1.0	269.0	5.0	5.0	5.0	284.0	285.0
Ocean	0.0	0.0	35.5	35.0	0.0	70.5	70.5
Total	**5,438.0**	**2,155.0**	**5,156.5**	**2,468.8**	**85.0**	**9,865.3**	**15,304.3**

Source: DOE website, NREP Book

The author has also analyzed these five-year targets and arrived at a similar conclusion: the RE-only additions are enough to cover the supply requirements every five years until the end of the planning period.

This is truly a remarkable result! It means that if the Philippine government's energy efficiency and RE targets were all on track, it would have been possible to meet all additional demand for the period 2012-2030 by renewable energy sources only.

This remarkable conclusion lurking within the government's energy plan has an equally awesome implication: it means that the country does not anymore need to include any new fossil-fueled (and nuclear) power plants in its electricity supply planning.

The door could finally be closed on these dirty, harmful and increasingly expensive technologies.

It did not happen

Unfortunately, this scenario did not materialize in the first four years of the plan under the Aquino administration. The RE additions were far below target, and the government went instead on a construction binge of more than 40 coal plants. Despite demand from RE operators for higher targets, energy planners kept applying the brakes on RE expansion, while pulling out all stops to coal construction.

Thus, the country today finds itself in a bizarre situation of locking itself to coal technology for the next 30 years or so, a technology that is going to be increasingly more expensive compared to renewables like solar and wind, while promising to the world to cut down its carbon emissions by 70% of the BAU scenario by 2030.

Some 40 years ago, President Marcos insisted on a nuclear plant even as negotiations made it more and more expensive. Similarly, President Aquino insisted on scores of coal plants, even if it was increasingly clear that these plants were going to produce more expensive electricity in the future.

Conventional wisdom poses two major objections to the RE-only scenario for new demand:

1) Solar and wind are expensive and will raise the retail price of electricity, a major concern of consumers.

2) Solar and wind have variable outputs. We need baseload plants—typified by coal- and nuclear-fueled plants—to keep the grid stable and electricity rates low.

Let us answer these two objections.

The retail price of electricity went down, not up, due to renewables

The conventional wisdom that renewables raise the price of electricity might have been true several years ago, but it is not true anymore.

A one-year study (Nov. 2014 to Oct. 2015) of the country's feed-in-tariff (FIT) system by Jonathan dela Viña of the Philippine Electricity Market Corp. showed that because renewables tended to replace the more expensive fossil-fueled peaking plants that only come online during periods of peak demand, renewables in fact brought the average price of electricity down.

The FIT system is part of the Renewable Energy Act of 2008 (RA 9513). It sets (through the Energy Regulatory Commission) fixed rates to be paid to qualified RE plant operators. These FIT rates vary per RE technology, but are typically higher than the average cost of generation, the difference representing the premium that the government (through the ERC) was willing to pay, to encourage private investments in RE. To pay this premium, the law adds a universal charge (initially, four centavos per kWh, also set by the ERC) to every utility consumer's electric bill. In effect, every consumer of electricity pays an extra charge to encourage private investments in RE.

Over the one-year period covered by the PEMC review, renewables actually saved the consumers a total of ₱4.04 billion, or ₱0.0567/kWh. This is what PEMC found:

Table 28. The PEMC findings

Consumer savings due to lower bill	₱8.29 B	
FIT charges paid by consumers	₱4.26 B	₱0.0406 per kWh
Net consumer savings from RE	₱4.04 B	₱0.0567 per kWh

Source: Macapagal, Jed. *Malaya*. Jan. 20, 2016; Lectura, Lenie. *Business Mirror*. Jan. 19, 2016.

Thus, although the feed-in-tariff (FIT) system collected ₱4.26 billion from consumers to pay renewable plant operators, these plants displaced the output of more expensive natural gas- or diesel-fed peaking plants, bringing down the average price of electricity and saving consumers a total of ₱8.29 billion, for a net gain of ₱4.04 billion. In effect, the FIT charges can be consider an investment; it was forced on consumers, but it earned them a 94.8% (4.04 divided by 3.26) return on investment, which is not a bad deal at all.

Because the prices of renewables keep dropping, we can expect even greater savings in our electric bills in the future.

The PEMC study involved solar and wind farms, whose output have to go through transmission and distribution lines. The final cost of the electricity, as it appears to the consumer will reflect not only the generation cost, but also transmission and distribution costs, system losses, metering charges, universal charges, taxes, and various other fees added on by the utility.

To consumers who install solar panels on their rooftops, the price of this electricity they generate themselves is only the generation cost. Rooftop solar owners free themselves from paying all those other add-on costs. In the Meralco area, the retail price of electricity today is around nine pesos per kWh, while the LCOE of solar rooftop electricity is around 8.50/kWh. Thus, electricity from one's rooftop is already the cheapest source of electricity in most parts of the Philippines today.

Unfortunately, many so-called 'energy experts' in government as well as in the academe still talk about solar reaching grid parity by 2020. They are obviously referring to utility-scale solar farms, whose output have to be distributed through the grid. Rooftop solar already passed grid parity around 2013!

Conclusion

This paper suggests an innovative approach in national planning for the electricity supply.

The approach involves adopting an intermediate goal that is focused on new supply requirements, taking the existing and committed supply capacities as given. In the context of the Philippine Energy Plan 2012-2030, it turns out that applying this approach would have resulted in a remarkable conclusion: the government's own energy efficiency and renewable energy targets were more than enough to supply all new demand with 100% renewable electricity. Had the government worked really hard to attain these energy efficiency and renewable energy targets, there would have been no need—since 2013—to build new fossil-fueled power plants.

If the incoming Duterte administration embraces this approach, it can make a giant step towards the energy transition to a renewable future and avoid a technology lock-in that will bind us to expensive and dirty energy technologies for decades to come.

Chapter 5
Unevenly distributed renewable potential

While we can generally conclude that solar, wind and hydro power are all financially viable options today, these renewable resources are unevenly distributed throughout the country—in absolute amounts, in their relative intensities, and in the regularity of their availability. In short, they are unevenly distributed in terms of quantity as well as quality. Some areas are gifted with more of one RE source than another, others have better of one or two of these sources.

Renewable resources are unevenly distributed throughout the country in absolute amounts, in their relative intensities and in the regularity of their availability.

This makes it a real challenge to determine the best mix of renewable technologies for a particular site.

The potential, relative intensities and the regularity of availability of these renewables must therefore be further determined at the provincial, city, municipal and even village levels. Doing so will make it possible to design the mix of technologies and approaches that will optimize the reliability, efficiency and viability of the entire system.

This will ensure that our village and town showcases of 100% RE are also cheaper for the local consumers as well as viable for low-risk, long-term financing. Then, we can initiate our first Feldheim-type showcases.

Locating and assessing RE resources

The following two tables summarize the RE projects which have already been awarded by or are still pending with the Department of Energy as of June 2016. They indicate the areas in the Philippines where one or another RE resource can be most financially viable. In a particular locality where several RE resources can be tapped in the right combination to create a highly attractive project that financial institutions can support, then the possibility of an RE project that meets our three conditions for an RE showcase can be considered.

Table 29. Awarded Projects Under Renewable Energy (RE) Law, as of June 2016

Resources	Awarded Projects		Potential Capacity MW		Installed Capacity MW	
	Grid-Use	Own-Use	Grid-Use	Own-Use	Grid-Use	Own-Use
Hydro Power	398	-	8,037.04	-	822.00	-
Ocean Energy	7	-	26.00	-	-	-
Geothermal	41	-	610.00	-	1,906.19	-
Wind	55	1	1,180.80	-	426.90	0.006
Solar	144	16	4,399.71	4.286	538.45	3.2181
Biomass	40	22	237.38	3.12	295.07	40.66
Sub-Total	685	39	14,490.93	7.406	3,988.61	143.88
TOTAL	**724**		**14,490.93**		**4,132.49**	

Source: DOE Website, https://www.doe.gov.ph/renewable-energy/Summary-of-Projects

The table above is a summary of approved RE projects. The next table summarizes the pending RE projects,

Table 30. Pending Projects Under RE Law, as of June 2016

Resources	Awarded Projects		Potential Capacity MW		Installed Capacity MW	
	Grid-Use	Own-Use	Grid-Use	Own-Use	Grid-Use	Own-Use
Hydro Power	157	-	3,849.25	-	-	-
Ocean Energy	2	-	-	-	-	-
Geothermal	2	-	60.00	-	-	-
Wind	26	-	291.00	-	-	-
Solar	114	1	2,916.00	0.39312	-	-
Biomass	14	2	157.70	8.00	-	-
Sub-Total	315	3	7,273.95	8.39	-	-
TOTAL	**318**		**7,282.34**		**0.00**	

Source: DOE Website, https://www.doe.gov.ph/renewable-energy/Summary-of-Projects

Let us look at the individual technologies.

Solar intensity distribution in the Philippines

Solar insolation and average daytime temperature maps for identifying potential sites for photovoltaic installations and other solar-powered equipment are available from NREL and also from NASA.

Here are some sample documents:

- Assessment of Solar Resources in the Philippines (NREL Internal Review Draft, October 2000), retrievable from: www.spug.ph/Solar.pdf.

- Interactive Solar Map, retrievable from: www.solargis.info/imaps.

- The Profile of Solar Insolation in the Philippines, retrievable from: solarelectricityhandbook.com/solar-irradiance.html.

- World Daily Solar Insolation Map, retrievable from: http://www.oksolar.com/abctech/solar-radiation.htm.

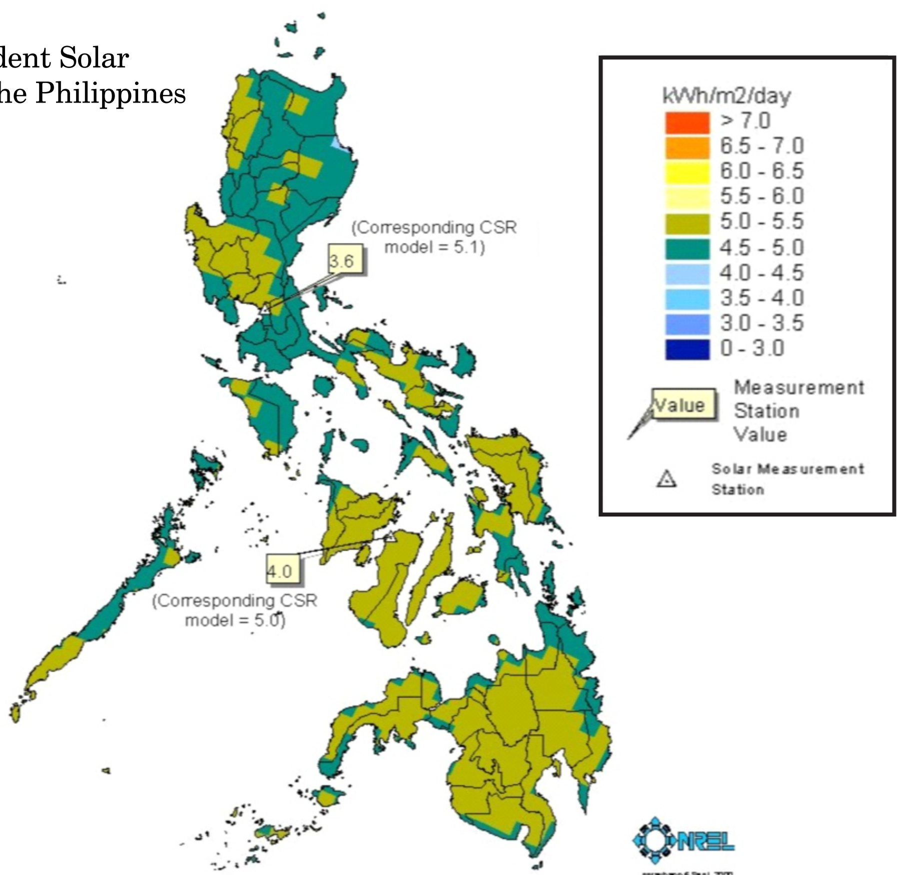
- Solar Dataset – UNEP, retrievable from www.unep.org.

- Solar Insolation (one month, NASA - NASA Earth Observations), retrievable from: neo.sci.gsfc.nasa.gov/view.php?datasetId=CERES_INSOL_M.

- DOE Solar Energy Potential Sites, retrievable from: www2.doe.gov.ph/ER/Maps%20-%20Solar.htm.

Maps such as the solar irradiation map in Figure 7 show how solar peak-hours are distributed throughout the country.

Figure 7. Incident Solar Radiation in the Philippines



Source: Renné, et al., 2000.

The latest among these aids in determining the potential RE resource in a locality is a project at the Imperial College London called “Renewable.ninja” (http://www3.imperial.ac.uk/newsandevents_pggrp/imperialcollege/newssummary/news_5-9-2016-16-22-36). The tool will make it easier for academics and the industry to estimate renewable output in any location, according to a report (Hayley Dunning, “New tool can calculate renewable energy output anywhere in the world”, Imperial College London News, September 6, 2016). The tool itself can be accessed at https://www.renewables.ninja/.

The welcome message to the site says: “Run simulations of hourly power output from wind and solar PV power plants by clicking anywhere on the map or using the location search box, choosing your technology from the side menu, and hitting 'Run'. You can also download ready-made data sets on our downloads page.” It prompts the site visitor with a simple form for inputting a location's latitude and longitude, the range of dates to be analyzed, and the resource (solar or wind). The output is a graph, which can also be downloaded as raw data in a CSV file suitable for spreadsheet analysis.

More tools with greater resolution are bound to be developed in the future.

Philippine wind maps

Wind studies result in wind maps that indicate averages and distributions of wind speeds in most parts of the country. The most comprehensive of these so far are those used for identifying potential sites for wind turbines. These maps and accompanying analysis of the distribution of wind power potential were prepared by the National Renewable Energy Laboratories (NREL) of the U.S. Here are some sample NREL documents:

- Philippine Wind Energy Resource Atlas Development (November 2000, NREL/CP-500-28903), retrievable from: www.nrel.gov/docs/fy01osti/28903.pdf.

- Wind Energy Resource Atlas of the Philippines (Feb. 2001, NREL/TP-500-26129), retrievable from: www.nrel.gov/wind/pdfs/26129.pdf, 206 pp.[23]

- Philippine Wind Farm Analysis and Site Selection Analysis (December 2001, NREL/SR-500-30934), retrievable from: pdf.usaid.gov/pdf_docs/PNADJ196.pdf.

- DOE Wind Energy Potential Sites, retrievable from: www2.doe.gov.ph/ER/Maps%20-%20Wind.htm.

The map in Figure 8, also taken from the NREL study, gives a good idea of the areas in the country which are good candidates for potential wind energy projects.

The 2014 wind energy survey update [24]

The latest wind potential assessment was released in March 2014. The latest assessment reflects recent technological developments and takes into account larger-sized and taller turbines. The encouraging findings of this updated survey indicate that average wind speeds

23 This atlas divides the Philippines into 13 regions and contains a detailed region-by-region analysis of the wind resource potential of the country.

24 Mark D. Jacobson, “Philippine Wind Resource Assessment: Modern Approaches to Support the Development of a Nation's Wind Energy Potential,” National Renewable Energy Laboratory (NREL), 2014, p. 30.

of greater than 6.5 m/sec can be found in 25% of the country at a tower height of 80 meters, and in 30% of the country at 100 meters. (Wind speeds higher than 6.0 m/sec are considered commercially relevant.)

Table 31. Average Wind Speeds and Specified Heights

Area surveyed (km^2)			
Height	**< 6.0 m/sec**	**> 6.0 m/sec**	**Total**
80 m.	220,968 km^2	74,889 km^2	295,857 km^2
100 m.	207,164 km^2	88,693 km^2	295,857 km^2

Source: Jacobson, 2014.

And as turbine heights and rotor diameters have increased over the years, the economics of wind energy have improved significantly, with costs going down from $150/MWh in 1995, to around $50/MWh in 2012, an average decrease over the 17-year period of 6.7% per year.[25]

Average wind speeds greater than 6.0 m/sec can be found in 25% of the country at 80-meter tower heights, and in 30% of the country at 100 meters.

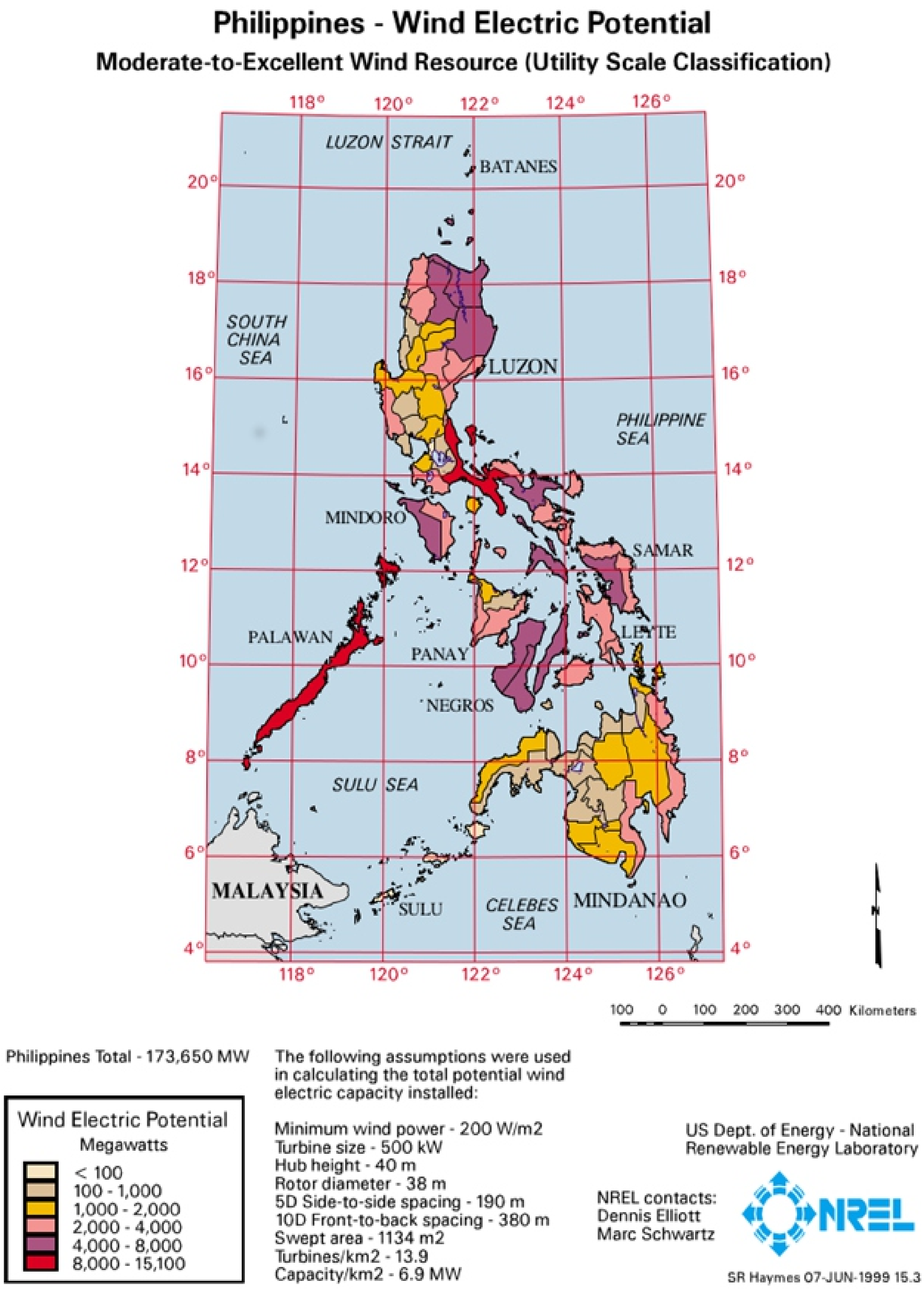
Table 32. Typical Energy Production from a 1.6 MW Turbine with 100m Rotor

Average wind speed (m/s)	Net energy (MWh)	Net capacity factor (%)
6.0	4,130	29%
7.0	5,321	38%
8.0	6,327	45%
9.0	7,134	51%

Source: Jacobson, 2014.

25 Jacobson, p.18.

Figure 8. Wind Electric Potential of the Philippines



Source: Elliott, p. 102

The 2014 NREL wind energy survey is much more useful for wind developers in the Philippines for the following reasons:

- data for various heights are now available: 30, 50, 80, 100, 140 and 200 meters
- the models used are based on latest generation technology
- not only average speeds are available but also their frequency (Weibull) distribution
- shear, wind direction, temperature, air density, and temporal information are also available now.

The Renewables.ninja site referred to earlier is a recent addition to the various tools that can be used to estimate wind potential in a particular locality.

A good indication of the wind energy potential of the country is the number of commercial RE developers, local as well as foreign, who have come knocking at DOE's door to take advantage of the RE Act and its FIT provisions.

The list of wind projects which have already been approved by the DOE can be found on the DOE website. The projects intend to exploit a total of 1,181 MW of wind energy potential. This total is only 0.68% (about two-thirds of one percent) of the 173,650 MW estimated wind energy potential of the country, places where wind speeds of at least 6.5 m/s allow wind turbine capacity factors of 30% or higher, making commercial operation a real possibility. Indeed, there is a lot of room for growth.

The wind projects being built today cover less than one percent of the wind energy potential of the country. There's a lot of room for growth.

Potential mini-/micro-hydro sites

The old Department of Energy website contains a resource map of potential micro-hydro sites.[26]

The Japanese government has been reported to be conducting a new comprehensive survey to update the country's assessment of its hydroelectric potential.

The list of hydroelectric projects approved by the DOE as of June 2016 is also on their website. These projects intend to exploit a total of 8,037 MW of hydroelectric capacity. More applications covering 3,849 MW of additional potential are still pending. Should all the approved projects materialize, they will cover 65% of the total hydroelectric potential (big and small, including micro) of the counter as estimated by the DOE.

Unfortunately, there is a tendency from some project applicants to get approval for a project covering a huge area consisting of several river systems, effectively giving them a monopoly on the hydroelectric resources in the area. Then they sit on the project and hardly do any development. Instead, they offer their DOE-granted monopoly for sale to the highest bidder. This in fact makes them energy speculators, who tend to drive up the long-term price of electricity in the country.

26 http://www2.doe.gov.ph/ER/Maps%20-%20Micro%20Hydro.htm

Other renewables

This study does not include much on biomass, biofuels, ocean and other renewable sources. These can be covered in subsequent studies or incorporated in subsequent editions of this study.

Some resource maps for these are also available on the old Department of Energy website:

- www2.doe.gov.ph/ER/Maps%20-%20Rice%20Residues.htm
- www2.doe.gov.ph/ER/Maps%20-%20Coconut%20Residues.htm
- www2.doe.gov.ph/ER/Maps%20-%20Bagasse.htm
- www2.doe.gov.ph/ER/Maps%20-%20Ocean%20Thermal.htm

A very good source of early information on biogas production and utilization is Maramba's account of the Maya Farms biogas project.[27]

It must be remembered that all data extracted from the databases above must be verified on the ground for a particular site under consideration, at least for a whole year, and preferably for two years or even more.

This is necessary to provide a reliable foundation for all the technical and financial calculations that will become the basis for evaluating the financial viability of a particular showcase.

We must also consider the ongoing electricity rates in a particular area. The higher the rates, the greater the reason to shift to renewables as soon as possible. Note that the latest Meralco residential rate (₱8.97/kWh as of July 2016) is significantly lower than the ₱12.00/kWh that Sec. Petilla used when he concluded that rooftop solar was cheaper than the Meralco rate. But even under the lower Meralco rates, rooftop solar is *still cheaper*. Sec. Petilla's conclusion was robust and remained valid despite swings in the electricity rates.

All data extracted from these databases must be verified on the ground for a prospective site, for at least a whole year.

In some parts of the country though, the retail price of electricity is still cheaper than electricity from solar rooftops (see Chapter 1 for details). But not for long, given the continuing decrease in solar PV costs.

Remember the *new* conventional wisdom: in most parts of the country, solar electricity from your rooftop is now cheaper than grid electricity.

27 Felix D. Maramba. *Biogas and Waste Recycling: The Philippine Experience*, (Metro Manila: Maya Farms, 1978).

Chapter 6
Financially viable RE projects

The case studies that follow involve a wide range of renewable energy projects.

Most of these projects are business ventures, undertaken by entrepreneurs who looked at the financial viability of the project and, after due diligence, decided that the venture makes commercial sense.

Commercial financing for the project additionally meant that a second opinion—the bank's—agreed with the entrepreneurs that their renewable energy venture was commercially viable. In fact, it meant that the returns on the investment were high enough, that the entrepreneur and the lending bank are *both* going to make money from the venture.

What could be a better argument, in addition to the calculations of the DOE Secretary himself, to prove that renewable electricity is now a financially viable prospect?

Lessons from the field: mainstreaming micro-hydro

In their book *Lessons from the Field: An Assessment of SIBAT Experiences on Community-Based Microhydro Power Systems*, the non-profit Sibol ng Agham at Teknolohiya (SIBAT) provides thorough documentation of their micro-hydro projects in 10 sites: [28]

Table 33. SIBAT Micro-hydro Projects

Site	Province	Date completed	Capital Cost, P	Capacity, kW	Capital Cost/kW	Util. rate, %	Household benefi-ciaries
Ngibat	Kalinga	1994	484,000	5	96,800	4.8	33
Tulgao-Dananao	Kalinga	1999	2,781,565	33	84,290	9.1	264

28 Sibol ng Agham at Teknolohiya (SIBAT), *Lessons from the Field: An Assessment of SIBAT Experiences on Community-Based Microhydro Power Systems* (Quezon City, Philippines: SIBAT, 2005), p.48.

Balbalasang	Kalinga	2001	2,503,594	20	125,180	14.6	154
Lon-oy	La Union	2001	1,875,253	15	125,020	11.1	78
Tabuk	Kalinga	2001		2			11
Kapacnaan	Nueva Vizcaya	2001	389,271	5	77,850	2.9	Pastoral Center
Buneg	Apayao	2002	802,000	7	114,570	5.9	33
Katablangan	Apayao	2002	972,000	10	97,200	3.2	42
Adugao	Abra	2002	731,500	7.5	97,530	3.3	16
Caguyen	Abra	2002	749,476	7.5	99,930		26
Kimbuta	Nueva Vizcaya	2003	915,400	7	130,770		13

Source: SIBAT, 2005.

The outputs were used primarily for lighting. In the larger installations, the outputs were also used for agricultural equipment (e.g., sugar press and rice mill), rural industry (e.g., woodworking and blacksmithing), and for small appliances and school computers.

The SIBAT experience shows that off-grid communities are good candidates for RE showcases. Most of their sites were not grid-connected, and therefore enjoyed 100% renewable electricity from the micro-hydro project. The tariff rates were set by the communities themselves, and were set at levels that the beneficiaries could afford.

Judging whether the projects were financially viable (in the Feldheim sense) is complicated by the fact that grant financing was the main source of funding, which eased the pressure on communities to maximize the utilization of the plants. This might partially explain the low utilization rates, which ranged from 2.9% to 14.6% only. (More recent SIBAT data indicate significant improvements.)

It is also worth noting that with these capacity factors and at today's prices, solar PV would probably be competitive with these plants in terms of capital costs per kW. Of course, other factors would still have to be taken into account, such as O&M costs, ease of installation, and capacity factor. Hydroelectric plants with capacity factors of 60% or higher will certainly be much more competitive than the current crop of plants whose capacity factors average less than 50%.

Off-grid communities are good candidates for RE showcases.

As the SIBAT experience shows, micro-hydroelectric plants continue to be a viable option for local generation of electricity.

The first commercial wind farm in the Philippines

The country's first commercial wind project, and Southeast Asia's largest for some time, is the 33 MW wind farm in Bangui, Ilocos Norte. The plant, which started operation ten years ago, supplies power to the Ilocos Norte Electric Cooperative. The wind farm is operated by the NorthWind Power Development Corporation, which is now under the Ayala group.

The third phase of the Bangui project, which will add another 18 MW to the wind farm, is also vying for FIT support.

CEPALCO's grid-tied 1-MWp PV power plant: a first in the developing world

The 1-MWp on-grid PV power plant of CEPALCO in Cagayan de Oro City went online more than ten years ago, on September 26, 2004. At the time of its inauguration, it was the developing world's first and largest power plant of its kind.

In its first three years of operation, the plant produced 4,169,100 kWh, an average of 1,389,700 kWh per year, and 10% higher than the expected output of 1,261,400 kWh per year.

In 2007, CEPALCO's plant supplied the needs of around 900 CEPALCO residential customers.

The 1-MWp plant cost CEPALCO around US$5.1 million to install. The plant consists of 6,500 167-Wp solar panels laid out on two hectares of land. The project was partially financed with a loan from GEF. The loan was facilitated by the World Bank through its International Finance Corporation. After five years of successful operation, the loan will be turned into a grant. Note the cost of $5.10 per Wp ten years ago, which made it necessary to provide the project with some financial support.

Sumitomo Corporation of Japan won the turnkey contract to build the plant. Another Japanese company, Sharp, made the PV modules while China's Sansha supplied the inverters. The balance of system components were procured locally.

The PV plant is designed to complement the 7 MW run-of-the-river hydroelectric plant owned by CEPALCO subsidiary Bubunawan Power Company.

The plant has attracted thousands of visitors, including 10,000 students and local, as well as foreign, renewable energy enthusiasts.

Due to its positive experience with PV technology, CEPALCO now plans to embark on a larger solar park within its service territory. The solar park will occupy 30 hectares inside the First Cagayan de Oro Business Park in Villanueva, Misamis Oriental, some 30 minutes away east of Cagayan de Oro City. A pre-feasibility study indicates that the plant can supply CEPALCO with around 14 million kWh per year of electricity, equivalent to some 30,000 barrels per year of fuel oil.

Figure 9. 1-MW Photovoltaic Power Plant,
Barangay Indahag, Cagayan de Oro City, Philippines

Source: http://philnews.ph/wp-content/uploads/2013/10/Cepalco-Solar-Power-Plant-500x218.jpg

The proposed 10-MWp PV plant will be constructed over five years, to take advantage of the best available solar technology in the market. Phased-in construction will enable CEPALCO to take advantage of the increasing efficiency and decreasing costs of solar panels, which account for around 50% of the PV plant's installed costs. Waiting for lower costs will cushion the plant's impact on CEPALCO's rates.

In May 2011, seven years after it went online, around 25% of the panels had been damaged by micro-cracks and one of the nine inverters had failed. Although the plant was still in working condition, it was only producing 50-60% of its rated output. Fortunately for the project, Sharp honored its 20-year warranty and replaced the defective panels.

A 40-50% loss of output after seven years is a major concern. Without a long warranty, or if the supplier did not honor its warranty (these are common problems in the Philippines), such rapid deterioration of PV panels would drastically change the economics of solar power. On the other hand, a 33-Wp ARCO solar panel's output is said to have degraded by only 8% after thirty years.[29] This wide variation in the quality of PV panels should be a warning to buyers to take special care in choosing suppliers. A dependable warranty from a reliable supplier that will still be in business at least 10 years later is of utmost importance.

A Pioneer Utility-Scale Solar Power Plant

Bronzeoak Philippines is a Negros-based Filipino corporation engaged in several renewable energy projects. The following details were gathered from a presentation by its President, Jose Maria Zabaleta Jr. on June 14, 2014 at the German Chamber of Commerce in Makati, supplemented by media stories about the project.

In partnership with a German company Thomas Lloyd, Bronzeoak formed the San Carlos Solar Energy (SACASOL), which set up in 2013 a 13-MW solar power generating plant. Other partners include Hua Goang and Conergy.

SACASOL's solar power plant is the first-of-its-kind plant to take advantage of the 2008 Renewable Energy Act. It is also the first to actually operate under the Philippine FIT system, with its FIT certificate of eligibility already signed by the DOE. They began feeding into the grid on May 15, 2014. The project took two years, from concept to completion. In answer to questions about bureaucratic delays, Zabaleta acknowledged that "around 120 signatures" were needed to get the project approved. (A later estimate, presented at the May 2016 Solar Summit held in Solaire Hotel, Metro Manila, put it at "more than 400".)

The cost of installing solar energy in the Philippines, Zabaleta says, is 3–4 times the cost of a similar facility in Europe. He cites as main reason the higher civil construction costs in the Philippines.

Zabaleta mentioned that another firm, the Majestics Energy Corporation, is implementing a solar generation project in Cavite. The firm has also completed construction and installation of its facilities, though it is not yet connected to the grid. The two companies alone, he says, will already fill up the 50 MW provided for under the FIT system. Because of this, the industry is expecting the DOE to raise the FIT-supported solar generation capacity from 50 MW to 500 MW.

The 13-MW SACASOL plant comprises the first phase of the project. Another 9-MW plant is scheduled for completion by "early 2015" — making up the project's second phase.

29 Williams, p. 335.

The first phase consists of 88,000 PV modules of fixed orientation. Each panel is rated at around 150 Wp. In addition, 22 inverters convert the solar farm's DC output to AC, to feed into the grid. The 13-MW plant occupies 35 ha. By generating electricity from the sun instead of fossil fuels, the plant displaces 17,000 tons of CO_2 per year.

The next phases (B, C and D) will have capacities of 9, 13 and 10 MWp respectively, for a grand total of 45 MWp. These were all completed by August 2015. Three more solar farms are being built in Negros Island for completion in 2016: IslaSol I, IslaSol II, and Montesol, with capacities of 32, 48 and 18 MWp respectively. (http://www.sacasol.com/about.html).

The SACASOL solar power plant supplies electricity to the grid during the peak daytime hours, making it a "peaking plant." Thus, it is replacing not the lower-cost electricity from base-load bunker oil or coal-fueled plants but higher-cost electricity supplied by diesel-fueled peaking plants. In fact, the weighted average of peak prices at the Wholesale Electricity Spot Market (WESM), Zabaleta says, is "around 10 pesos". This is higher than the solar FIT rate of ₱9.68.

The output of solar farms at midday replaces the more expensive output of diesel-fueled peaking plants. Thus, solar farms actually reduce, not raise, the price of electricity.

- Zabaleta

So, the solar power plant actually reduces the cost of electricity during peak hours, according to Zabaleta, by avoiding the use of diesel-fueled peaking plants. In a separate interview with media, Zabaleta asserted that typical diesel-fueled peaking plants produce electricity at a cost of ₱22 per kWh. This strongly suggests that even household-, building-, enterprise- and community-scale PV installations will be commercially viable for their owners, who can sell their output to the grid during peak hours, once the barriers to their entry are eliminated.

That renewables that come online during peak hours reduce the price of electricity has been confirmed by a study of the Philippine Electricity Market Corporation (PEMC). In a study covering the period November 2014-October 2015, PEMC found that while consumers paid a total of ₱4 billion in FIT charges, the average reduction in electricity prices due to renewables coming online during peak hours totaled ₱8 billion in that one-year period, resulting in a net benefit for consumers of ₱4 billion.

In response to questions about possible damage from typhoons, Zabaleta says the project is insured. No bank will finance such a project if it is not insured, he added.

In 2008, Bronzeoaks also set up a bio-ethanol plant that produces 40 million liters of ethanol and 60 million kWh of electricity per year. In addition, a 20-MW biomass-fueled generating plant is in the works. Another 18-MWp solar farm in La Carlota, Negros Occidental is scheduled for grid connection in 2015. The plant cost ₱1.8 billion.

Is SACASOL's solar venture a profitable one?

Let us do the calculations:

The venture required total investments of ₱1.9 billion (other reports say $41.7 million) for 22 MWp of solar generation capacity. Using a typical capacity factor of 18%, we can calculate the venture's expected energy production per year as follows:

22 MW × 0.18 × 1 GW/1,000 MW × 24 hrs/day × 365 days/year = 34.7 GWh = 34,700,000 kWh

This figure agrees closely with company press releases saying that the solar plant's expected energy output is 35 GWh per year.

With the solar FIT rate fixed at ₱9.68 per kWh, the venture's potential gross sales in electricity is therefore ₱336 million per year, or ₱28 million per month.

On the other hand, a ₱1.9 billion investment, assuming it was borrowed from banks at an interest rate of, say 9% (a typical bank lending rate in 2014), and payable over 20 years, would require a monthly amortization of ₱20.9 million per month.

It truly seems like a viable investment, with a potential monthly gross income of around ₱7.1 million per month. Of course, we can assume that SACASOL would have exercised due diligence and done a much more detailed feasibility study to convince their investors and lenders that their investment would generate the rate of return they are after.

Note by the way that $41.7 million for 22 MWp is around $1.90 per Wp, a 62.7% decrease compared to the $5.10 per Wp cost of CEPALCO's solar PV plant ten years ago. This means an average price drop over the past ten years of 9.4% per year[30] for utility-scale solar farms.

Over the past 10 years, the investment cost for solar PV farms has dropped by 9.4% per year.

Note, finally, that solar electricity profit margins have become big enough that banks can now come in, take their share in the form of interest payments, and still leave enough for the investors and their suppliers. If the margins are now attractive for investors, they should even be more so for solar rooftop owners, who do not have to worry about transmission and distribution costs.

A 5-kWp residential rooftop PV system owned by a Makati businessman

Mike de Guzman's family owns several businesses, including a hotel, an apartment building and a call center. His Makati home has three bedrooms and a second floor.

The de Guzmans used to pay an average of ₱24,000.00 per month in electric bills. Faced with even higher rates in the future, he decided to install a 5-kWp solar PV system in the roof of his house. The heart of the system consists of 20 solar panels, producing 250 Wp each. Every month, the system produces around 675 kWh of electricity, worth roughly ₱8,000.00 at current rates (₱11.00–₱13.00 per kWh).

30 $5.10 \times (1 - 0.094)^{10} = 1.90$

Today, because he buys electricity from Meralco only when the sun goes down, his monthly electric bill hovers around ₱12,000.00. When the sun is up, the solar panels provide de Guzman with electricity for free. When the sun really shines, de Guzman's monthly bill goes as low as ₱9,000.00, and the panels produce as much as 34 kWh in one day, enough to power a one-horsepower air conditioning unit for 45 hours. In fact, when the PV system produces more electricity than he can use, he just keeps his three air conditioners on.

The worst-case scenario is a payback period of 10.4 years; a payback period of 4.2 years is the best case scenario.

The whole 5-kWp solar PV system cost de Guzman ₱500,000.00, or ₱100.00 per Wp, which is the going rate today for PV systems without storage batteries. According to de Guzman, the system's payback period is five years. Three years earlier, such a system would have cost around twice as much, but China's entry into large-scale PV production has flooded the world market, including the Philippines, with cheaper solar panels, controllers and inverters. De Guzman gives as example a Chinese-made inverter which he recently bought for ₱47,500.00, and compares it to a US-made one that cost him ₱216,000 earlier. An inverter converts the solar panels' DC output, like a storage battery's, into AC, like the output from an electric outlet in the house.

Based on de Guzman's figures, the worst-case scenario occurs when you invest ₱100.00 per peak-watt and save only ₱9.60 per year per peak-watt of investment, resulting in a payback period of 10.4 years. The best-case scenario is when you invest ₱100.00 per peak-watt and manage to save ₱24.00 per year per peak-watt of investment, resulting in a payback period of 4.2 years.

De Guzman's experience is a direct confirmation of Secretary Petilla's statement that households which generate their own electricity from solar panels will save money.

De Guzman claims that 25 years after they are installed, the solar panels will still be producing 80% of their original output.

You can look at the solar savings in at least two ways:

- If the money that bought the solar PV system came from your own pocket, you will recover your investment within ten years, probably shorter.

- If the money that bought the system was borrowed from the bank, taking out a ten-year loan at 9% will result in a monthly installment that is more or less equal to the amount you will be saving monthly from your utility payments. A longer-term loan, on the other hand, means smaller monthly payments to the bank. Then, you will actually be earning some money, on top of the savings on your utility bill.

Most households, however, will not have the money to pay for the upfront costs of a solar PV system. Thus, the main obstacle that prevents an immediate conversion to solar by households is financing.

Given the right financing, Mike de Guzman's experience suggests that it now makes economic sense for every household to start converting to solar power today.

Seeing the economic viability of a solar PV system from his personal experience, de Guzman decided to go into the business himself and set up Solaric, a company that sells and installs PV systems. Solaric's services today include helping its customers apply for Meralco's net metering and POP programs.

Mike de Guzman's case is typical of a number of business-oriented individuals, who tried solar PV systems either out of curiosity, out of a sense of participation in ecological advocacies, or in search of new ventures, and found enough low-hanging fruits that can be harvested from the solar PV market to justify going into business themselves. They have struck gold.

Small-scale solar projects will be perfect not only for small- and medium-scale enterprises (SMEs) in the Philippines but also poor households. See, for instance, this story about a 10-watt installation from solarenergyph.com/tag/solar-power-cavite/.

The local solar PV industry is currently enjoying robust expansion, and the market will probably explode in the next few years, creating new jobs for designers, installers, maintainers, repair specialists, and technicians as well as niches for import-replacing local industries.

Germany found the job-creation aspect of the solar industry a major reason to justify institutional support. Today, Germany's solar industry employs more people than its coal industry.

Power purchase agreements (PPA): The right business model for solar?

Leandro Leviste is the president of Solar Philippines. His company's mission, he says, is "to offer solar energy cheaper than fossil fuel, paving the way for its adoption by every home and business in the country."

Leviste's business model is different from the usual suppliers and installers who sell the solar PV equipment in cash or terms, or who provide service in installing and maintaining such equipment.

Instead, Leviste installs his own equipment, at his own expense, on his customers' premises. In exchange, customers sign a long-term contract committing to buy the electricity produced on their premises—rooftops, actually—by Leviste's solar PV equipment. Thus, instead of spending high upfront costs, the customer starts saving money on the very first day the system goes online.

Solar Philippines assumes the upfront costs of setting up the solar PV system. Its customers start saving on the first day of operation.

The power purchase agreement is similar in essence to the PPAs signed by the government in the past with independent power producers.

Leviste's first project under this model was the 700-kWp solar PV installation at the Central Mall Biñan, Laguna. The 2,514 panels used cover some 7,000 m^2 of rooftop. The set-up, Leviste claims, is "the largest self-consumption [solar] power plant in Southeast Asia." Under the power purchase agreement, the company operating Central Mall, Premiumlink, buys electricity from Leviste's company at a rate cheaper than the electric utility's rates, resulting in monthly savings of more than 100,000.00 for Premiumlink.

Leviste's model solves the biggest barrier today to consumers who want to go solar: the high upfront costs of solar electricity. They are being asked, in effect, to pay today their monthly consumption over the next five to seven years. Even if the long-term calculations indicate that they will save money that way, most consumers balk at the prospect. Leviste's model removes this barrier, because his company assumes the risks of financing the project upfront. In fact, this is logically the way it should be. Given Leviste's familiarity with the technology, he already knows that the risks are low, although most customers and the public do not know this yet.

Secretary Petilla himself recognizes the innovativeness of Leviste's approach, when he said at the inauguration of the Central Mall solar project, "The problem has been the business model and this is the first company to get it right... I commend Solar Philippines for bravely pioneering this zero up-front scheme, which is an obvious choice for customers."

At this time, Central Mall is not yet 100% solar, though. The 700-kWp system installed on their rooftops is big enough to replace only 30% of its electricity consumption. This conservative approach is understandable. Consumers, and possibly Leviste himself, since this is his first major solar project, are still testing the waters.

The problem has been the business model. This [Solar Philippines] is the first company to get it right.

Former DOE Secretary Petilla

Leviste's next project is larger, a 1,400-kWp solar installation in SM North Edsa, which is operated by SM Prime Holdings, Inc.[31] The project is scheduled for commissioning by the first half of 2015. It will supposedly make SM North Edsa "the largest solar-powered mall in the world."

This is not the first solar project for SM Prime Holdings, either. They had earlier installed in 2013 a 1,100-kWp solar PV system in SM City Xiamen, their first shopping mall in China.[32] However, their Xiamen solar project followed the more traditional model of self-financed solar installations. SM Prime Holdings spent around $2 million for the project. Whether this is only the first of what could be a series of solar installations in SM malls, SM Prime Holdings' chief finance officer, Jeffrey Lim said, "We will consider installing in other locations subject to successful implementation of our first project in the Philippines."[33] Like the others, they are also testing the waters.

31 "Mall to construct biggest solar rooftop in the Philippines," *Yahoo Philippines*, October 20, 2014, https://ph.news.yahoo.com/mall-construct-biggest-solar-rooftop-philippines-193941066.html.

32 "SM Prime building largest comm'l solar rooftop," *The Philippine Star*, June 26, 2014, http://www.philstar.com/business/2014/06/26/1338931/sm-prime-building-largest-comml-solar-rooftop.

33 Philippine Daily Inquirer, "Biz Buzz: SM going solar," SM Investments Corporation, September 26, 2014, http://sminvestments.com/biz-buzz-sm-going-solar.

That a local bank, the Bank of the Philippine Islands (BPI), is financing Leviste's projects could be a signal that banks have taken notice of the significant savings realized when shifting to solar. The savings are obviously considerable since there are now enough to split between the electricity consumer, the project developer and the source of financing. JoAnn Eala, who heads the BPI's sustainable energy finance and specialized lending, has been quoted saying, "Funding is not a problem, as banks, like the BPI, have financing programs that also provide free technical advice."[34]

If other banks get into act, especially if the government makes commercial lending to solar and other renewable project even more attractive, this can significantly speed up the energy transition to renewable electricity.

Leviste claims that his company is growing phenomenally. "Our company is now constructing more than 10 times the amount of solar rooftop installations that were installed in the entire Philippines in 2013," he says. For 2014 alone, they are targeting the installation of solar PV systems in seven shopping malls in the country. Aside from Central Mall Bi an and SM North Edsa, these include Robinsons Palawan and CityMall Roxas City. The CityMall chain alone is planning to build some 100 community malls in the country, all of which will have solar PV systems, according to its owner Edgar Sia II.[35]

By first half of 2015, Leviste expected to have installed 50 MWp of solar PV systems[36]—as much as the DOE's initial target for the entire country for 6–7 years.

Since residential electricity rates are 50% higher than commercial rates, the potential savings are even greater for residential customers. All it needs is the willingness of banks to finance residential installations.

If these pioneering efforts are successful and Leviste's business model is adopted widely not only in the commercial but also in the residential sector, solar PPA's can be a game-changer. It can open the floodgates to the installation of solar PV panels in every rooftop in the country, ushering the energy transition to renewable electricity.

By the first half of 2015, Solar Philippines will have installed 50 MWp of PV systems, as much as the DOE's target for the whole country.

Unfortunately, Leviste's company is afflicted with the typical business bias against small customers. Its PPA business model is available only to big customers like the SM Megamall, but not to households. Residential customers still have to pay for the upfront costs of a PV system. Solar Philippines' entry-level system (as of early 2015) was a 1.5-kWp grid-connected battery-less system which sells for ₱174,000.00 (₱116.00 per kWp).

The Philippines today badly needs businesses that, unlike Leviste's Solar Philippines, will cater to lower-income groups and bring to them the benefits of solar power which the rich are now enjoying.

34 Doris Dumlao, "A power plant on every roof," *Philippine Daily Inquirer*, September 22, 2014, http://business.inquirer.net/179216/a-power-plant-on-every-roof.

35 Ibid.

36 "Mall to construct biggest solar rooftop." Yahoo Philippines

Geothermal electricity: 40% cheaper than prevailing rates

A 40-MW geothermal plant being built for $185 million in the barangays of Montelago, Montemayor and Melgar-B in Naujan, Oriental Mindoro by the Filipino-owned Emerging Power Inc. (EPI) will go online in the second half of 2016. The EPI is getting technology support from Iceland and Indonesia for this project.

The geothermal project was granted by the government's Board of Investments tax incentives that include income tax holiday for seven years; duty-free importation of machinery, materials and equipment; cash incentives for missionary electrification; and tax credits on domestic capital equipment and services.

Martin Antonio Zamora, the EPI chair, committed to sell geothermal electricity in Mindoro for ₱6.58 per kWh, 40% lower than the utility's generation costs which are based on bunker fuel.

Mindoro will enjoy geothermal electricity that is 40% lower than utility generation costs.

Projects such as these can perfectly complement wind and solar projects to enable localities to enjoy 100% renewable electricity at rates cheaper than the grid rate, and where the renewable energy providers are at the same time commercially viable.

More recently, however, the EPI project has been embroiled in environmental concerns typical of big energy projects. The company has been accused of violating the conditions attached to its Environmental Clearance Certificate (ECC). (Evora, Robert, "Former solon slams Mindoro 'geo' project", *Manila Standard*, March 18, 2015, http://www.thestandard.com.ph/news/-provinces/172970/ former-solon-slams-mindoro-geo-project.html)

Utility-scale wind power: 54 megawatts in Guimaras

The Wind Energy Development Association of the Philippines (WEDAP) sees the Philippines as having the potential of becoming a leader in wind energy production in Southeast Asia because of the abundance of wind sites. The group is composed of 14 companies, including Trans-Asia Oil and Energy (del Rosario group), Energy Development Corporation (Lopez group), PetroEnergy Resources and UPC Renewables.

The list of wind power projects that have been awarded service contracts by the DOE is in their website (www.doe.gov.ph).

More than 700 MW of Philippine wind projects were on the pipeline in 2014, most of which were targeted for completion by 2015. However, the ERC put a cap of 200 MW on wind projects that will get FIT support. Thus, like their solar counterparts, wind project developers are engaged in a race to complete their wind plants and connect to the grid ahead of the others.

The leading contenders in the wind race included the Ayalas, Trans-Asia (54 MW in Barangay Sebaste, San Lorenzo, Guimaras), Nabas, and EDC of the Lopez group (87 MW in Burgos, Ilocos Norte).

Once the 200 MW are filled up, which NREB Chairman Pedro Maniego Jr. said may happen by the end of 2014, the late finishers are out of luck. They will not enjoy support through FIT, which includes priority dispatch and the guaranteed rate of ₱8.53. They will then have to look for buyers themselves, or try their luck at WESM. Maniego says that the wind cost per KWh is lower than WESM rates. However, the risk of not being able to sell their output will make the life of the late-finishers certainly complicated and possibly miserable.

One of the leading contenders for FIT support among wind projects is TAREC's 54-MW wind farm in San Lorenzo, Guimaras, which involves a total investment of 6.453 billion.

The TAREC wind farm will take advantage of the seven-meter-per-second average wind speeds in the province. The project will erect 27 wind turbines, each capable of generating a maximum output of 2 MW. The total output will be sent via submarine cable to the Ingore, Iloilo substation, connecting it to the Visayas grid.

The TAREC wind farm is the first wind power project in the Visayas. It is expected to be fully online by the end of 2014. The wind project follows the heels of San Carlos Solar, whose 22-MWp solar power plant in Negros Oriental went online in May 2014 with an initial output of 13 MWp.

The 54-MW Trans-Asia wind farm in Guimaras involves a total investment of P6.453 billion.

Sixty-five percent of the project is financed by a consortium of local banks. The rest is investor equity.

This is the first project of TAREC, a wholly owned subsidiary of Trans-Asia Oil and Energy Development Corporation, the energy arm of PHINMA, which is the holding company of the Del Rosario group. The project was also registered and approved by the Board of Investments, as well as by the DOE under the Renewable Energy Act of 2008. The Act entitles the project to income tax holiday, duty-free equipment importation, and other incentives.

PHINMA's other energy businesses include a small 3.2-MW electric power plant in Guimaras, a 21- MW power plant at the Carmelray Industrial Park II in Calamba, Laguna, a 116-MW power plant at the Subic Freeport, and a 52-MW power plant in Norzagaray, Bulacan.

Let us do the calculations for the TAREC project:

We will assume a capacity factor for the 54-MW project of 25%, which is conservative for wind projects. Ideal sites, such as Bangui in Ilocos Norte, actually have capacity factors of 30% or more. Based on our conservative assumption, the project is expected to produce 9.7 million kWh of electricity per month. At the guaranteed FIT rate of ₱8.53 per kWh, it therefore expects a gross income of ₱83 million per month.

The TAREC project involves an investment of ₱6.453 billion for 54 MW of wind power, or ₱120 million per MW. Assuming an interest rate of 7.5% per annum payable over 15 years, the cost of capital alone is around ₱60 million per month.

This leaves it around ₱23 million per month for operating and maintenance costs, plus profits of course. This is a bit tight for the company, because the O&M costs for wind farms are definitely higher than solar farms. It will therefore have to watch its costs carefully, if it wants an acceptable profit margin. If TAREC manages to increase its turbines' capacity factor to 30%, its gross can go up to ₱99.6 million, giving it a more comfortable ₱39.6 million to split between the O&M costs and profits.

That a difference of 5% in actual wind capacity factor may spell the difference between comfortable and tight profit margins is a sobering thought.

Anti-wind advocate Ozzie Zehner, for example, claims that "when countries or regions start to install wind turbines, the average capacity factor goes up at first, then levels off or declines as additional turbines are sited in less-ideal conditions. For instance, between 1985 and 2001, the average capacity factor in California rose impressively from 13 percent to 24 percent, but has since retreated to around 22 percent. Over the years, Europe's maturing wind farms have stabilized below 21 percent. The US average is under 26 percent, according to field readings from the [US] DOE."[37]

While Zehner has his own agenda, his claims that wind capacity factors tend to be over-reported by the wind industry need to be double-checked especially by businesses that are setting up wind farms in the Philippines. It is of course logical to assume that before investing several billion pesos into their projects, these businesses would have done due diligence and did actual site measurements over long periods, to determine for themselves the wind potential in their chosen site, including such issues as transmission line capacity.

The 240-MW pumped storage is a perfect complement to the FIT-supported solar (500 MW) and wind (200 MW) projects that are coming online soon. As the energy transition to renewables accelerates, more pumped storage will be needed by the grid.

Big hydro too

A large 350-MW hydroelectric complex approved by the DOE in August 2014 and consisting of three plants will be built in Ifugao by a joint venture of Norwegian SN Power and the local Aboitiz Power. The three components of the complex include a 100-MW hydroelectric plant, a 240-MW pumped-storage project and a 10-MW mini-hydro, all in Ifugao Province. The joint venture is called SNAP-Ifugao.[38]

The 240-MW pumped-storage component will complement perfectly the FIT-supported solar (500 MW) and wind (200 MW) that are coming online soon.

37 Ozzie Zehner, *Green Illusions: The Dirty Secrets of Clean Energy and the Future of Environmentalism* (Lincoln/London: University of Nebraska Press, 2012), p. 52–53.

38 "Philippines approves energy contract for 350-MW SNAP-Ifugao hydro complex," Hydro Review and HRW-Hydro Review Worldwide, August 12, 2014, http://www.hydroworld.com/.

This is not the first hydroelectric project for the group, which also operates the 105-MW hydroelectric plant in Ambuklao, the 126-MW plant in Binga, and the 360-MW plant in Magat.

As wind and solar costs go further down, and the energy transition to a renewable future accelerates, more pumped-storage facilities will be needed by the grid. Eventually, as rooftop solar becomes as ubiquitous in the future as desktop computers are today, more and more storage facilities should be connected to the grid to complement the naturally variable output of solar and wind power.

It may now make sense, as solar panel costs go down even further, to study the feasibility of retro-fitting existing dams (especially stepped dams like those of the Agus River in Lanao, for instance) to turn them into pumped-storage that can handle the rapid expansion of solar electricity.

In the future, it will be desirable for almost all hydro facilities to have some water impounding capacity, so that they can play the role of flexible plants that can rapidly ramp their outputs up or down in response to changes in demand as well as supply from wind and solar. Flexible plants will play an essential role in the grids of the future, when variable renewables like wind and solar have become a major source of cheap electricity..

In the next chapter, we will see what policies have evolved to encourage renewable energy development.

Chapter 7

Helping renewables grow: Policy options

Globally, a whole range of policy options have been tried to encourage RE development, with varying success. Judging from dramatic and steady growth of its RE sector, the German model has been the most successful so far.

We will review below the range of policy options that have been explored in different countries, as policy advocates, lobbyists, and activists groped for ways to hasten the entry and growth of renewables within their country's energy mix.

1. Government subsidies

Subsidies are of course a common government approach towards industries and sectors they want to encourage. The subsidies have usually taken the form of tax exemptions or rebates for the purchase and installation of RE equipment.

This was, for instance, the approach taken by Japan: rebates to household PV installations.

From the energy crisis in 1974 to around 1993, over a 20-year period, the Japanese government spent $5 billion to subsidize solar PV systems. This led to applications like solar-powered watches and calculators, with little other results to show.

Undeterred, the Japanese government once more initiated what they called the "New Sunshine" project, which subsidized 50% of the installation cost of residential PV systems. The goal was to create a market for PV systems for the Japanese solar industry. They cut down the subsidy to 33.3% in 1997. By 2001, Japan boasted of more than 77,000 "solar roofs."[39] The program reached its apex in 2004, having subsidized a total of 400,000 homes. At this point, the subsidy was down to 3%. In 2005, the subsidy was finally phased out.

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39 Daniel Yergin, *The Quest: Energy, Security, and the Remaking of the Modern World* (New York: Penguin Press,

Without government support, however, PV prices rose and fewer people were willing to buy. Within two years, the demand for PV systems in Japan was down by 50%.

If the Japanese, with their deep pockets, cannot afford to continue subsidizing RE development, then it would clearly be even harder for more cash-strapped countries to do so. Japan's case was a clear lesson in the limitations of government subsidies, at least in the case of renewables.

Japan's case was a clear lesson in the limits of government subsidies.

When South Korea launched its own FIT program, it tried to finance the whole thing with government funding. Like Japan, they quickly found out that the approach was hard to sustain.[40]

At least one case of government subsidy seems to have worked very well, the U.S. Investment Tax Credit (ITC) for residential and commercial investors in solar energy generation. Residential ITC is a 30% credit in solar investments, applicable to a homeowner's personal income tax, when the homeowner makes an outright purchase of a solar PV system for home installation. The commercial credit, also 30%, applies to businesses that install, develop or finance solar projects, including solar farms. The U.S. ITC is currently scheduled to last until 2019, after which the credit declines to 26% in 2020 and 22% in 2021. After 2023, it will drop to 10% for businesses and 0% for homeowners. The ITC has been quite successful, helping the U.S. sector grow by more than 70%/year—spectacular growth by any measure. (http://www.seia.org/policy/finance-tax/solar-investment-tax-credit)

However, the obvious bias against homeowners does not make sense, given that the technical, economic and social benefits of residential solar outweigh those of solar farms.

2. Renewable Portfolio Standards (RPS): Mandated targets

Under this approach, the government sets targets in terms of the absolute (MW or MWh) or relative (%) share in capacity or consumption of renewables in the overall mix. The government then requires its energy department or the industry to meet these targets. In the Philippines, the "Renewable Portfolio Standards" (RPS) incorporated in the Renewable Energy Act are a form of mandated targets.

To be effective, the targets must come with clear incentives for compliance (like subsidies) or punitive measures for non-compliance. If not, they will become no more than wish lists for policy makers.

3. Mandated grid sell-back (aka "priority dispatch")

One of the early policy breakthroughs by RE advocates, now routinely accepted by policy-makers, was to allow RE developers to connect to the electric grid and to require utilities to credit RE developers for excess production that they send back to the grid.

Before this, it was unthinkable for utilities to even consider their customers, especially households and other small players, as suppliers of electricity. Thus, payments to households

40 Johnstone, p. 192.

for excess RE production was out of the question. In the past, early RE pioneers had to find creative ways of consuming excess energy, when they were not allowed to connect to the grid much less to get credits for sending their excess production into the grid.

This acted as a major brake on further RE development.

Even today, in many countries, selling excess RE production to the grid is a continuing struggle.

As RE advocates everywhere pushed for their governments to mandate grid connections and grid sell-back by RE pioneers, the principle was eventually accepted and firmly established. The renewable foot was in the door.

However, utilities continue to put barriers towards its implementation. They impose huge connection fees, demand very expensive "impact studies" whose costs are to be shouldered by RE producers, require bulky documentation, bind RE producers to iniquitous contracts, process connection applications at a glacial pace, and pay very low rates.

Thus, even today, in many countries, it is a continuing struggle for RE adopters to sell their excess production back to the grid, and many simply abandon the idea. Once they produce enough for their own electricity needs, there is no more reason for them to expand their RE capacity further.

4. Financing innovations

Several major financing innovations have been tried in the US—all with good effect.

Solar leasing. *S*olar leasing was pioneered by a US start-up company called SolarCity. Customers leased the solar PV system from SolarCity, which retained ownership and maintained the system. Customers signed up for a 15-year lease, with no down payment. As soon as the system started operating, the customers started saving money, without the high upfront costs of solar electricity.

Three months after SolarCity introduced solar leasing, their business had grown by 300%. Within four years, the company grew from two employees in 2006 to 630 in 2010. In 2016, SolarCity merged with electric car manufacturer Tesla, in an effort the exploit the synergies between the storage requirements of renewables and electric vehicles. (Megan Geuss, "Antitrust regulators approve Tesla deal to buy SolarCity", *Ars Technica*, Aug. 26, 2016, http://arstechnica.com/business/2016/08/antitrust-regulators-approve-tesla-deal-to-buy-solarcity/)

Power purchase agreements. Another approach solved the upfront cost problem not with a solar lease but with a PPA. This approach was pioneered by SunEdison (Baltimore) and MMA Renewable Ventures (San Francisco). Instead of leasing solar PV equipment, customers entered into a contract to buy power from PV suppliers, who installed their solar PV systems on the customers' premises. And the customers bought it for a fixed rate, which was cheaper than the utility rate. The PPA duration was typically eighteen years. The contracts then served as collateral for bank loans that would cover the upfront costs.

The pioneers of PPA focused on big customers, like supermarkets, who bought electricity produced from the PV equipment installed by the suppliers. Another company, SunRun, saw the benefit of the approach and focused on residential customers.

Under a solar lease, the customer still had to worry everyday whether it would be cloudy or not. Under the PPA approach, the customer would only pay for the electricity that the PV panels actually deliver. Without risk, they started saving money on the first day the panels start delivering electricity. The PPA approach was so effective that SolarCity, the solar leasing pioneer, adopted it too, giving its customers two options: a long-term solar lease, or a long-term power purchase agreement.

Financing innovations: solar leasing, power purchase agreements, and loan payments via property taxes

In the Philippines, the pioneer in solar PPA's is Leandro Leviste's company, Solar Philippines.

Loan payments as property taxes. In 2007, Berkeley, California tried a third financing innovation: making financing payments part of property taxes. They called it property-assessed clean energy (PACE). The PACE approach went this way: homeowners would borrow money from the city to finance the installation of their solar PV system. This loan subjects the homeowner to a special tax, which goes towards repaying the loan over a 20-year period. The liability was not attached to the homeowner but to the property. Thus, if the property changed hands, the new owners would assume the tax liability.[41]

This arrangement involved a very low financing risk, because property taxes usually get priority, even when the property is foreclosed.

Berkeley initially budgeted $1.5 million to pilot the program, good for 40 installations. The whole amount was applied for within nine minutes!

Subsequently though, Berkeley changed tack and decided to require private financing for the program, delaying the expansion of its originally successful program.

The idea of PACE financing, however, was picked up by others and is gradually spreading in the U.S. and elsewhere. PACENation is a website that tracks the developments in this innovative solar financing strategy. (http://pacenation.us/)

5. Net metering

Net metering was a major advance in mandated sell-backs, because of two major advantages: a) it could be implemented very simply; and b) consumers got a better deal for their RE surplus.

Net metering is very simple. The electric meter runs forward when the user is getting electricity from the grid. It runs backward when the user is supplying electricity to the grid. At the end of the billing period, the meter reading automatically reflects the net balance of the electricity consumption for that period. This offsetting of kilowatt-hours automatically results in a common reference price ("parity pricing") for the electricity coming in and going out.

Utilities do not have to do anything, for net metering to happen. They do not even have to know that it is happening, just like they do not have to know that consumers have turned off their air conditioners or their heaters to save electricity.

[41] Johnstone, p. 236–237

All the consumer needs is a specific type of inverter that could synchronize its output with the grid's and use all the available self-generated electricity first before letting into the house wiring a single watt of electricity from the utility. When clouds obscure the sun, the inverter automatically lets more utility electricity in. When the sun comes out again, the inverter uses less electricity from the utility. When the solar panels generate more electricity than what the house needs, the surplus goes out to the grid, for use by the nearest neighbors, and the consumer's electric meter turn in reverse, transferring the liability for the exported electricity to the neighbors, whose meters will each register how much of the exported electricity they used.

Net metering is a major advance because it is so simple in concept and operation and because the consumer gets a better deal. Under the old sell-back mechanism, consumers paid the full retail price for electricity from the utility, but got credited only the smaller generation charge for selling back to the grid. Under net metering's parity pricing, the electricity cost the same, coming in or going out.

Net metering is such an important advance that we will devote several chapters to this approach.

CSI: California dreaming

In 2006, under the California Solar Initiative (CSI) plan, the following combination of policy mechanisms was tried in California:[42]

- **Rebates**. Using funds collected from ratepayers, some $3.2 billion would be made available in rebates over an 11-year period, using funds already collected from utilities and some additional funds to be collected from ratepayers. These rebates are scheduled to end this year (2016).

- **Mandated targets**. All new homes (a 100% target) coming in by 2011 were mandated to include solar power as standard.

- **Net metering.** Up to 2.5% (only!) of electricity sales were to be acquired under net metering.

- **Tax credits on investments**, up to 30%, were included. These would be degressed (i.e., reduced according to a fixed schedule) as the plan approached its targets.

The ambitious plan floundered on a similar combination of poisoned pill and bureaucratic red tape.

The poisoned pill was a provision in the plan which required those who applied for rebates to accept the utilities' "peak/off-peak" (also called "time-of-use") pricing plan. The plan would charge them higher rates during peak periods. Unless one's PV system was large enough to take him off the grid, he would in fact end up with a higher bill under the provision.

In addition, the California Public Utility Commission left the implementation of the plan to the utilities themselves. This made it easy for the utilities to sabotage the plan. They delayed the payment of rebates from a few months to 7–10 months. They required a much more detailed application form, a one-page form bloating to 49 pages. The utilities also tacked on insurance requirements to the net metering agreement with customers, including deal-breakers such as indemnification in case of breakdowns.

42 Johnstone, p. 230–232

Plain-and-simple net metering would have been better.

The California experience shows various ways by which utilities can sabotage a well-crafted RE promotion program. In California and elsewhere, utilities close ranks, put up all kinds of barriers, and drag their feet whenever customers come forward to generate electricity on their own, especially when customers generate enough surpluses that they can actually sell back electricity to the utility.

The California experience shows how utilities can sabotage a well-crafted RE promotion program

Although California's population was only one-half that of Germany, it installed each year under the plan a tiny one-tenth of what Germany was putting online. Its target of installing 1,940 MW in the period 2007-2016 would merely average a 194 MW/year, truly insignificant considering that the Philippines installed 500 MW of solar in its first round of solar FIT projects. These puny targets were disproportionately matched by a gargantuan budget of $2.167 billion for the same ten-year period. Since by 2008 the money for subsidies was also running out, California's approach was leading to a dead end.

Plain-and-simple net metering, which requires zero subsidies, would have been much better.

This chapter discussed options that promote renewables. In the next chapter, we will look some practices directed against renewables, in particular, against self-generation.

Chapter 8
Uni-directional meters keep out the poor

For several years now, some Philippine utilities have been quietly replacing the old bi-directional analog electric meters with uni-directional meters.[43] In the process, they are putting in place the single most effective device in keeping low-income households out of the ongoing solar revolution.

The common analog meter reverses properly when power flows through it in the opposite direction. Thus, it is bi-directional and works perfectly with net metering. This kind of electric meter is consistent with the reference in the Philippine RE Act to a "two-way connection to the grid."

Uni-directional meters, on the other hand, record consumption in the forward direction, whether power is flowing into or out of the meter. This means that utilities will be charging instead of crediting solar owners who contribute their surplus to the grid. The result is truly perverse: the more a solar owner contributes to the grid, the higher their electric bill. In effect, the installation of uni-directional meters empowers the electric utility to financially *punish* customers who try to become less dependent on the utility by installing their own solar PV systems.

This effect has actually been documented by researchers.[44]The deployment of uni-directional electric meters has also been acknowledged by the Philippines' biggest utility Meralco, which calls it "non-reversing metering".

Even the smallest system, if it connected to the grid through a grid-tie inverter, will be exporting electricity to the grid some of the time. This is because many daytime appliances

43 This information was obtained confidentially from some electric utility workers.

44 Erees Queen B. Macabebe et. al., "Performance of a 3-kWp grid-tied photovoltaic system in a water refilling station" (Paper presented at the 5th International Conference on Sustainable Energy and Environment: Science, Technology and Innovation for ASEAN Green Growth, 19-21 November 2014, Bangkok, Thailand).

are not turned on all of the time. Lights will often be switched off in the daytime. Refrigerators and air-conditioners turn on when the temperature is above the thermostat setting, but turn off when it is below the thermostat setting. In short, they are *intermittent* loads. In low-income households, if both husband and wife are at work, and the children are in school, a grid-connected solar PV system regardless of size, will be exporting some surplus, and lots of it on cloudless days.

As long as solar owners are grid-connected, their solar surplus will follow the physics of electricity and will spill out into the grid automatically, just like water seeking paths of least resistance.

And if the utility has replaced the solar owners' electric meter with a uni-directional one, the latter are going to be charged the full retail price for every kWh they export. This exported surplus will be used by neighbors, registering on their electric meters. *Aside from charging the solar owner, the utility will also charge the neighbors for the same kWh*.

Sizing solar panels small enough to avoid a surplus will not work. When they leave for work, or if they happen in the daytime to switch off enough appliances or lights, they will still have a solar surplus and this will spill out into the grid. And then the utility's uni-directional meter will register this export as consumption, penalizing them severely, while the utility itself accumulates undeserved earnings from solar power without having invested anything.

Thus, the uni-directional meter serves the function of a padlock to the door that leads to solar independence. And the key is held by the electric utility.

There are several ways that a prospective solar owner can escape this virtual prison:

1. Disconnect from the grid altogether and store the surplus in a battery. This option, however, raises the total cost of the system significantly (by up to 100%, depending on battery size), and demands more from the owner in terms of regular maintenance;

2. Buy a gadget (which may cost a few thousand pesos), that detects when the grid-tie inverter starts to export (more expensive inverters may have this feature built in) and which then, at that point, curtails the inverter output or disconnects the inverter from the grid. The surplus is wasted, but at least the solar owner is not charged for it.

3. Apply to the utility for net metering, so that they will replace the uni-directional meter with a bi-directional one. However, this option is also expensive: the solar owner will have to bear the cost of replacing the meter, the cost of a "distribution impact study" (around nine thousand pesos for small systems), the cost of getting a local government permit for the installation, etc. Finally, Philippine utilities will only credit the solar owner about half instead of the full retail price of the exported surplus, a practice which is in fact contrary to law. This will be discussed in more detail in subsequent chapters.

The distribution impact study (DIS) requirement for net metering is a cruel joke on poor households. Suppose a household manages to get a loan and installs a 250-Wp panel and a corresponding grid-tie inverter (cost: around ₱25,000-₱30,000). The utility then charges the household nine thousand pesos to study the impact of the 250-Wp panel on their distribution system. (For context, remember that a 300-watt desktop computer consumes more, a 1-HP air conditioner consumes three times as much, while a 1,500-watt microwave oven consumes six times as much.) *The next household with a 250-Wp panel who applies for net metering will again be charged nine thousand pesos, so that the utility can study once more the impact of this tiny installation on the utility's distribution system.* And so on for every household that applies for net metering. It is, for all intents and purposes, a scam against the poor.

The well-off may very well be able to afford and shrug off the exorbitant net-metering fees and charges, but low-income households cannot. So, the door that leads to generating one's own electricity and contributing at the same time to pollution and carbon reduction remains padlocked at this time by the utilities.

Unfortunately, the government has turned a blind eye on these obvious efforts by some utilities to put up barriers against the spread of rooftop solar. Thus, while the biggest energy businesses in the Philippines feast on the low-hanging fruits of the energy transition to renewables, low-income households and small businesses are left to the mercy of electric utilities who see these small players as threats to their monopolistic business models and punish them severely for daring to become energy independent, raking in undeserved income along the way.

Properly implemented, net metering is one of the best ways to promote small-scale renewables. The next several chapters will show how net metering really works, if done properly, and how utilities try to mangle it to sabotage this excellent policy option.

Chapter 9
Net metering: origin and short history

Net metering in context

Before we go deep into net metering's history, it is necessary to remind ourselves why we badly need to promote solar rooftops as well as clean renewables as rapidly as possible. This need is driven by the following global trends:

1. **Environmental.** Especially after the Paris climate talks in November 2015, the world has awakened to the increasingly destructive impacts of extreme weather events and other associated long-term consequences of global warming and climate change, putting on the main agenda of every country the urgent need to reduce carbon emissions and to hasten the energy transition to renewables. The issue goes beyond climate change, of course. The toxic pollutants in nuclear and fossil-fuel power plant emissions are also a major concern.

2. **Political.** The insecurity in the global oil supply due to political instabilities in the Middle East remains a major concern, making it difficult for any oil-dependent economy to undertake long-term energy and economic planning.

3. **Economic.** The price declines in the solar and wind industry have reached the point where in service areas where the electricity rates are relatively high, solar electricity from rooftops has become the cheapest source of electricity. The approval today of any nuclear-, coal- or oil-fueled power plant will lead to a 30- to 40-year lock-in that will saddle the next generation with technologies that are not only harmful to health and toxic to the environment, but are also increasingly more expensive.

This might also be the right time to remind ourselves, especially the utilities, why rooftop solar needs all the support we can give it. Among the renewables, rooftop solar holds the biggest promise as a clean energy source because of the following competitive edge:[45]

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[45] This list of solar competitive advantage was taken from the author's speech before engineers and scientists of the Energy Development Corp. on January 8, 2016.

Largest price declines. Solar PV has shown the largest decline in prices. The general trend over the past four decades has been a 20-22% decline in PV prices for every doubling of cumulative production,[46] which translates roughly to a 9% decline per year.

Cheapest per-kWh price. In many service areas in the Philippines, rooftop solar is already the cheapest source of electricity, an unheralded milestone which former Energy Secretary Jericho Petilla noted in August 2014.[47] As solar PV prices drop, others will follow suit over the next few years. Electricity from solar rooftops avoids all transmission and distribution costs, as well as other add-ons to the grid electricity price, like metering charges, VAT and other taxes, system loss charges, universal charges, etc. Thus, solar rooftop electricity enjoys a built-in competitive edge over all other grid-delivered electricity. Their cheaper output also replaces expensive electricity from fossil-fueled peaking plants, helping bring down the average cost of electricity;

Lowest system losses. Longer wires have more resistance and larger losses. Even hydro, wind, geothermal and biomass electricity have to pass through transmission and distribution lines to reach consumers. Rooftop solar electricity has the shortest distance to travel from source to load. By reducing the burden on existing power plants, transmission lines and distribution networks, solar rooftops also delay or avoid altogether the need to invest in such infrastructure, helping keep electricity prices low.

Smallest incremental investments. Solar PV investments can be done in small affordable steps, from a few watts to a few kilowatts for households and small business establishments, to a few megawatts for utility-scale solar. Potential solar owners can start small, to take advantage of the solar benefits that can already be enjoyed today, and save their larger investments for the future, while waiting further price declines and better technologies.

Least impact on transmission and distribution lines. By generating electricity without putting any additional load on existing high-voltage transmission and distribution lines or requiring the construction of new ones, they avoid the cost of investing in new lines for new customers;

Most accessible to low-income households. No other technology today can do better than rooftop solar in enabling ordinary households to generate electricity themselves, instead of buying it from a monopoly. Accessibility is not only a matter of price. The sun is also more universally accessible than steady winds, steep river flows, underground heat, or biomass.

Shortest implementation times. Complete solar PV systems can be bought off-the-shelf and installed in a few hours. Larger systems may take a few days. No other technology, renewable or not, approaches the short install times enjoyed by rooftop solar.

Least environmental impact. Solar rooftops are the only energy source under which you can sleep soundly, without worrying about hazards to your health, safety and the environment. The health and environmental impact of solar PV manufacturing is by no means zero, but they are more easily mitigated and solved, compared to the super-massive impacts of nuclear and fossil fuels. They help phase out fossil fuel-based generating plants that cause local air and water pollution, emit climate-changing greenhouse gases, and displace local communities;

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46 IRENA. *Renewable Energy Technologies: Cost Analysis Series* (Vol. 1: Power Sector). "Solar Photovoltaics". June 2012. p. 12. www.irena.org%2FDocumentDownloads%2FPublications%2FRE_Technologies_Cost_Analysis- SOLAR_PV.pdf

47 "DOE Sec. Petilla: Renewables Pave the Way to Energy Security in the Philippines," Department of Energy. http://www.doe.gov.ph/news-events/events/announcements/2473-doe-sec-petilla-renewables-pave-the-way-to- energy-security-in-the-philippines.

Most reliable long-term source. The sun is the most reliable source of energy. Humanity cannot deplete it or use it up. It rises predictably every morning. Even ifregularly covered by clouds, its output over a week, a month or a year can still be predicted with good accuracy. And with better weather prediction tools, our ability to predict solar output with greater certainty will improve over time. Solar panels are often the only reliable source of energy in typhoon- and flood-hit areas. They also help improve the country's energy security by relying on locally available sunlight instead of imported fuels.

That is a lot of benefit, considering the relatively small effort required from government in supporting rooftop solar. Solar owners do not need any government subsidy. But they need the government to keep utilities off the backs their backs.

Clearly, we have all the reasons to provide the most favorable enabling environment for this technology. Given the various positive externalities generated by solar rooftops, the government rightly decided to encourage solar owners to keep replacing their consumption with solar electricity from their rooftops, so that not only the neighbors but also the whole country can benefit from the cleaner electricity. That is why net metering is in the RE Act.

If implemented in Philippines in the same effective manner as it has been in much of the U.S., net metering can be expected to open the floodgates to the solarization of rooftops. This will enable the general public to participate in the ongoing renewable energy transition, not just as passive buyers of electricity but as active producers themselves, engaging the utility through a peer-to-peer exchange model that has already proven itself in the information industry and is also emerging as a potential game-changer in the energy industry.

The origin and a short history of net metering

Figure 10. Steven Strong discovered net metering

The world's first net-metered connections occurred in 1979, in the U.S. state of Massachusetts, when 28-year old architect and solar pioneer Steven Strong put solar photovoltaic (PV) panels in his two building projects, a 270-unit apartment complex called Granite Place with a 5-kWp system added on, and a Department of Energy–funded solar house called the Carlisle House with a PV system integral to its design. The story of Strong's innovation is told by Bob Johnstone is his book *Switching to Solar*: [48]

"The Carlisle House as it was called featured passive solar heating . . . plus 126 solar electric panels capable of generating a whopping 7.3 kilowatts mounted on its southern-facing roof. More accurately, the PV panels were the roof. . . .

"The Carlisle House was designed to draw utility power from the grid when necessary. Conversely, when the solar cells were turning out more power than the house could use, the excess power would be fed back to the utility. A small meter mounted on the wall of the dining room told the story in kilowatts. When the utility power was drawn it ran forward. But when the PV was pumping out excess power, it ran backward. . . ."

48 Bob Johnstone, *Switching to Solar: What We Can Learn from Germany's Success in Harnessing Clean Energy* (New York: Prometheus Books, 2011), p. 91

The curious thing about Strong's innovation is that "he had forgotten to inform Boston Edison, the local utility, of his plan to feed excess wattage into its distribution network." The electric utility was unaware that net metering was already happening. The potential was there all along. Strong was just the first to discover and use it. Johnstone continues Strong's story:

> *"Strong mentioned his concern to the building's co-owner, a developer of Irish descent named Peter O'Connell. The latter did not hesitate. He asked Strong whether the solar system was ready to turn on. On being informed that it was, O'Connell simply threw the switch. Nothing went bang, everything worked as planned.*
>
> *"In June 1979 . . . O'Connell invited Carter to attend the grand opening of Granite Place that September. Once the president had accepted, the developer invited various local dignitaries including the governor, the state energy secretary, and senior executives from Boston Edison. But Carter had to cancel at the last minute, sending Denis Hayes as replacement. In his speech, the director of the Solar Energy Research Institute conferred his blessing on the utility for allowing power from the building's PV panels to be fed into its grid. The state energy secretary said essentially the same thing. When the utility executives' turn to speak came, they had little choice but to praise the project, too. Interconnection was, for the moment at least, no longer an issue.*
>
> *". . . power companies were delighted to bask in the positive publicity that flowed from being seen supportive of renewable energy. This was especially welcome at a time when so much bad publicity was associated with the shutting down of malfunctioning nuclear plants like Boston Edison's Pilgrim power station on Cape Cod Bay. In 1983, the utility commissioned Strong to build a solar-powered energy-efficient house in Brookline, Massachusetts. Impact 2000, as the house was dubbed, subsequently became the subject of a series on public television, a wonderful PR coup for the power company."*

That was how the discovery called net metering got to an auspicious start. Soon, solar and wind pioneers throughout the U.S. were connecting their setup to the grid too. Strong eventually won a number of awards for his solar work. The U.S. Department of Housing and Urban Development granted him a $156,000 award for Granite Place; *Time* magazine named him environmental "Hero of the Planet" in 1999; the American Solar Energy Society gave Strong the society's highest honor—the Charles Greeley Abbot Award—for "achievement in the advancement of solar energy applications" in 2001.

Since his meter reading reflected his net electricity consumption, Strong called his innovation "net metering".

Strong's innovation came just in time. Earlier, solar PV systems were always operated off the grid, for self-consumption only. Solar panels had been so expensive that they made sense only when no grid access was possible. Off-grid operation, however, required properly-sized batteries, a careful balancing of supply capacity and demand levels, a particular set of technical skills, and regular maintenance. When the batteries were fully charged, the output from the expensive solar panels went to waste; when the batteries were discharged, they had no power. These substantial requirements and limitations, on top of the high prices, prevented the widespread adoption of solar technology.

Solar panels were still very expensive in 1979, but prices have dropped enough for pioneering innovators like Strong to try them, even where grid access was available. U.S. solar advocates immediately saw the advantages of Strong's innovation over off-grid operation. In effect, Strong had discovered a novel way for solar PV systems to use the grid—as a giant battery — and a simple way to record and account for the energy exchanges that would occur. Once the system was connected to the grid, the physics of electricity and the electronics associated with solar panels ensured, round-the-clock, that the surplus in-house electricity went out to the grid when there was more than enough, and the right amount of electricity from the grid came in when the in-house supply was not enough. Net metering solved the problem of accounting for the ins and outs of electricity when the grid was used for storage, opening the door to the widespread adoption of renewable technologies, especially solar panels, as their prices continued to drop.

The idea spread gradually in the 1980s. In 1981, the Arizona Corporation Commission approved net metering below 100 kW, the first among U.S. public utility commissions (PUC) to do so.[49] The next year, the Massachusetts PUC followed suit. In 1983, Minnesota became the first U.S. state to enact a net metering law. More state PUCs and legislatures followed suit: the Indiana and Rhode Island PUCs in 1985, the Idaho and Texas PUCs in 1986, the Maine PUC in 1987, and the New Mexico and Oklahoma commissions in 1988.[50]

Japan, an early adopter

The net metering idea crossed the Pacific in the 1990s. In June 1990, Japan's Ministry of International Trade and Industry (MITI) announced highly simplified regulations for residential PVs that wanted a grid connection. The Japanese Federation of Electric Power Companies volunteered to introduce a net metering program based on parity pricing by 1992. The first to take advantage of the new program was a Sanyo engineer and solar researcher, Yukinori Kuwano, who connected a 2-kW PV system to the grid in July 1992. Net metering would eventually be tried in Canada, Europe, Australia, Brazil (2006), Mexico (2007), Sri Lanka (2009), Uruguay (2010), Lebanon (2011), Argentina (2012), India (nine states as of 2014), Chile (2014), Pakistan (2015), and several other countries. Germany would pioneer another successful approach, the feed-in-tariff.

At this point though, outside of pioneering Minnesota, net metering in the U.S. was still a matter of regulatory process or mostly a do-it-yourself effort. It took root or not depending on the whims of local utilities or the openness of regulatory commissions to innovative ideas. However, things were about to change. Let us hear this time Johnstone's story about legal researcher Thomas Starrs:

> *"As a student researching the causes of the 'wind-rush,' the sudden surge of investment in wind energy in California during the early eighties, Tom Starrs had what he modestly described as 'a minor epiphany.' Namely, that the main driver for investment in renewable energies had virtually nothing to do with any recent advances in the technology. Rather, it was energy policy that played the most important role. Investment in wind had been rooted in the tax breaks that state and federal law had made available to developers . . . .*
>
> *"Armed with this insight, in December 1992 Starrs invited himself to a meeting of the Photovoltaics for Utilities Group (PV4U) in Stuart, [Florida]. . . . Starrs stood up and introduced himself. He explained that he was a graduate student at the University of California at Berkeley looking for a meaty topic into which to sink his teeth. 'I sat down, and this guy literally in front of me, who I didn't know, had never seen before, leaned back in his chair, and sort of whispered out of the corner of his mouth — "net metering!"*

49 Chris Larsen, Bill Brooks and Tom Starrs, "Connecting to the Grid: A Guide to PV Interconnections Issues (3rd ed.)", 2000, p. 18.

50 Yih-huei Wan, "Net Metering Programs," NREL/SP-460-21651, December 1996, p. 1-3.

"Starrs had no idea what the stranger meant. Nor that this was Steven Strong, the architect who . . . had the previous decade designed and built the world's first grid-connected solar electric house and who by now probably had more experience with PV-powered houses than anyone else in the US. When the session was over Starrs got together with Strong. The latter explained what he meant by the term 'net metering.' The basic idea was simplicity itself. It exploits the fact that the rotating aluminum disk on the garden-variety electric meter used to track the number of kilowatts a household consumes in a given period—usually a month—has the ability to spin backward as well as forward. This ability meant that net metering of solar electricity could be introduced for residential customers with no change to the existing equipment.

"Net metering is essentially an accounting mechanism based on parity pricing: any excess electricity generated by photovoltaics (or other form of generation) flows out to the grid. It is automatically credited to the customer at the same—that is, retail—rate as electricity flowing in from the grid. The meter spins backward, effectively erasing a portion of the total charged. 'Net' simply means the final figure read out at the end of the billing period. Starrs was entranced by the concept. It seemed to him that net metering was the obvious way to simplify the often-byzantine process of connecting small systems to the grid. Also, to provide an answer to a complex question: What is the value of electricity generated and delivered within the distribution system? As Starrs knew from his work on the policy arena, it pays to keep things simple.

"Starrs wrote the first-ever paper on net metering. In June 1994, he presented the concept at an American Solar Energy Society conference in San Jose, California. The paper caused quite a stir. '. . . Afterward I was just barraged with questions and business cards. That's when it hit me that, for whatever reason, this issue really resonated with people.' "

Six months later, at the 1994 First World Conference on Photovoltaic Energy Conversion in Hawaii of the Institute of Electrical and Electronics Engineers (IEEE), with some 900 attendees, a working group was formed to propose net metering as a policy option for government. Their target: the California state legislature. When the group considered who should draft the bill, "the heads of the other six or seven people around the table all immediately swiveled to look at me," Starrs relates. So, with two other colleagues, he ended up writing the draft legislation that will require utilities to accept the scheme. To make the bill more palatable, Starrs' draft described net metering not as a sale of electricity from the solar rooftop owner to the utility but an exchange of energy. His drafting team also formulated "a set of rules that would simplify the process of interconnecting these systems in a way that more or less eliminated the utilities' project-specific discretion over the interconnection." As Johnstone described it:[51]

"The proposal was that, so long as the PV system's inverter—the device that converts continuous direct current output by the panels to alternating current in sync with the grid—met certain technical specifications, then the utility would be obliged to accept that inverter as the interface. The power company would not retain the ability to impose any additional requirements regarding interconnection. There was legal precedent for this argument. For decades AT&T had battled in the courts to maintain its monopoly on what equipment customers could plug into their wall socket. The phone company argued that interconnection of telephones made by anybody other than its manufacturing arm, Western Electric, would compromise the stability and reliability of its network. Starrs had studied the epic anti-trust telecoms lawsuit in grad school. He knew how eventually the regulator had ruled that any manufacturer willing to meet certain standard specifications could make and sell devices to the consumer."

51 Johnstone, p. 119.

To make a long story short, Starrs' draft passed the California legislature unanimously in 1995, and California became the second state to do so after Minnesota.[52] In the lobbying process, however, the local utilities still managed to limit the law's impact. Only installations of 10 kW or lower could participate in the scheme, and an overall system cap was set at 0.1% of the local utilities' peak demand.

Net metering researcher Yih-huei Wan of the U.S. National Renewable Energy Laboratory (NREL) identified the following reasons why net metering programs were subsequently adopted by more state legislatures and public utility commissions:[53]

> *"The main objective for states implementing net metering programs is to encourage private investment in renewable energy resources. Other goals include stimulating local economic growth, diversifying energy resources, and improving the environment. The appeal of net metering arises from its simplicity: the use of a single, existing electric meter for customers with small generating facilities. After the program is implemented, no regulatory interaction or supervision is needed. As a policy option, it makes renewable energy technologies more economically attractive without requiring public funding. Net metering also addresses a perceived equity issue of utilities gaining an unfair advantage over customers by paying customers only avoided cost but charging them retail price of electricity."*

By this time, however, utilities had turned hostile. They now saw net metering as a threat to their business model. Closing ranks, they would henceforth lobby strongly against the scheme and find various ways to undermine it even if it was adopted as policy. The battle lines were being drawn.

Supposedly following California's lead, Hawaii also enacted a net metering statute in June 1996, but with a different outcome. NREL researcher Yih-huei Wan tells the sad story:[54]

> *"Hawaii's net energy metering law mandates the use of two meters (one to record total consumption and the other to record total generation). Customer generators are billed for the electricity they use at the utility retail rate, and the utility credits the customer generators for the electricity they generate at a rate determined by the PUC based on the utility's incremental cost of energy. This requirement prevents the customers from using generation to offset their own consumption, thus denying customers the most important benefit of net metering. . . . Therefore, it is more appropriate to classify the Hawaii net metering law as a simultaneous purchase and sale agreement for small customer-owned generators rather than a net metering law."*

Net metering spreads

Despite stiffening opposition from utilities, some 16 U.S. states had a net metering program by 1996,[55] going up further to 22 U.S. states by 1998. Of the 22, six enacted net metering laws, 14 established net metering programs via public utility commissions and the regulatory process, and utilities in two states implemented a net metering program voluntarily.[56] In 2000, the number had gone up to 30.[57]

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52 Yih-huei Wan, "Net Metering Programs," NREL/SP-460-21651, December 1996, p. 2.

53 Yih-huei Wan, "Net Metering Programs," NREL/SP-460-21651, December 1996, p. 2.

54 Yih-huei Wan 1996, p. 7.

55 Ibid., p. 1.

56 Yih-huei Wan and H. James Green, "Current Experience with Net Metering Programs", Presented at WindPower '98 Bakersfield, CA USA, April 27-May 1, 1998, p. 3.

57 Larsen et al., p. 18.

In 2001, California RE advocates managed to pass a temporary measure raising the maximum size allowed for net metering from 10 kW to 1 MW, opening the scheme to larger structures and business establishments. The measure would end August 2002. A major legislative fight ensued, with solar advocates trying to extend the measure, and utilities trying to stop its extension. The measure was extended, but utility lobbyists managed to insert deal-breaking amendments. Net metering credits for large-scale solar producers were reduced by up to 50%. Customers were required to install an additional meter, at the customers' expense, unnecessarily complicating the scheme, as well as making it more expensive. An enthusiastic businessman who was also an environmentalist, Fred Adelman, submitted his net metering application for a 30-kW system immediately, on the day the 10-kW cap was lifted. He received an email from PG&E requiring that before he could connect to the grid, an engineering impact study would have to be performed at the customer's expense. Nothing happened for a month. When Adelman called PG&E to follow up, he was informed that he would be charged $605,000 because the company would have to upgrade their local distribution network first. Adelman eventually got the charges reduced to $11,000, but only after a long and costly legal battle.[58] In short, even with a net metering law passed, hostile utilities continued to sabotage the program.

The year 2012 was a watershed: that year, 99% of all installed PV systems in the U.S. were net-metered.[59] The trickle of do-it-yourself citizens who now had the means to generate their own power was turning into a flood. In September 2012, alarmed U.S. electric utility executives gathered in Colorado and agreed that distributed generation (DG) in general and net metering in particular was a "disruptive technology" that threatened their centralized business model with "declining retail sales," "loss of customers" and "potential obsolescence." They decided to launch a major effort to stem the tide. Their main target: net metering and its parity pricing feature.[60]

The "net metering war", as some accounts put it, began in earnest in 2013. By this time, there were net metering programs in 43 U.S. states and the District of Columbia.[61] South Carolina became the 44th in December 2014.[62] Where net metering is not mandated by law or the regulators, utilities usually credit those who send their surplus to the grid the avoided cost of the exported electricity, which is usually lower than retail price.[63] The battles, however, continued to rage. As a 2013 news story put it:[64]

> *"The fate of rooftop solar net metering—the credit homeowners get for putting kilowatt-hours on the grid—is being fought in states across the country . . . . Utility companies, which make their money selling electricity from centralized power plants, have sought or are seeking to limit the payments for the distributed generation coming from thousands of solar panels.*

58 Johnstone, p. 219-220.

59 Vera von Kreuzbruck, "US: 99% of installed PV systems in 2012 were net-metered projects", *PV Magazine*, April 17, 2013. http://www.pv-magazine.com/news/details/beitrag/us—99-of-installed-pv-systems-in-2012-were-net-metered- projects-_100010943/#axzz3Ud9FFkF9

60 Joby Warrick, "Utilities wage campaign against rooftop solar", Washington Post, March 7, 2015, http://www. washingtonpost.com/national/health-science/utilities-sensing-threat-put-squeeze-on-booming-solar-roof-industry/2015/03/07/2d916f88-c1c9-11e4-ad5c-3b8ce89f1b89_story.html

61 Tom Tanton, "Reforming Net Metering: Providing a Bright and Equitable Future," American Legislative Exchange Council, March 2014.

62 http://www.solarserver.com/solar-magazine/solar-news/current/2014/kw51/south-carolina-becomes-44th-us-state-with-solar-pv-net-metering.html

63 Yih-huei Wan and Green, p. 1.

64 Mark Jaffe, "Rooftop solar net metering is being fought across U.S." The Denver Post, September 1, 2013, http://www.denverpost.com/business/ci_23986631/rooftop-solar-net-metering-is-being-fought-across.

“The Edison Electric Institute, which represents investor-owned utilities, has identified distributed generation as a potentially 'disruptive technology' that could compete with utility companies . . . . “In state after state, utility companies are seeking to change net-metering programs.”

This campaign has already gained success in some States like Hawaii.[65] More States are considering the option.[66]

As more and more solar owners demand net metering, utilities are frantically campaigning today to discredit and roll back this effective policy option for promoting rooftop solar and other small-scale renewables.

65 “PUC Approves New Programs; Ends Net Metering”. Maui Now. Oct. 14, 2015. http://mauinow.com/2015 /10/14/ puc-approves-new-programs-ends-net-metering/

66 “16 U.S. States consider changes to net metering”. *PV Magazine*. Aug. 17, 2015. http://www.pv-magazine. com/ news/details/beitrag/16-us-states-consider-changes-to-net-metering_100020629/#axzz3wGrWv3Sb

Chapter 10
Net metering is an exchange, not a sale

This chapter will explain the significance of net metering in the overall energy transition to renewable electricity.

Behind its very simple implementation, net metering in fact involves a complex set of transactions that will become increasingly common as more and more households install solar panels on their rooftops or solarize their entire roofs using solar shingles.

When electric utilities enjoyed a monopoly of distributing electricity to consumers, it was unthinkable for a consumer to be sending electricity into the grid and getting credit for it. Today, as the prices of solar panels continue to decline, households and businesses now routinely contribute to the grid supply, fundamentally altering the paradigm of electricity generation and distribution.

We are entering a new era when consumers can generate electricity more cheaply on their own, thanks to the continuing decline in the price of solar panels. Since the panels' output may not be enough some of the time, or more than enough at some other times, the need for the grid will not disappear. But the nature of its role will change, from merely supplying electricity to exchanging electricity with those who produce more than enough and with others who are not producing enough. Accounting for these novel bi-directional transfers of electricity is more complicated than the earlier situation where the utility supplied all the electricity and its customers just consumed it. This simpler client/server model will increasingly be challenged by a peer-to-peer model, and buy-and-sell arrangements will be increasingly replaced by peering arrangements and peer exchanges.

In the course of accounting for these exchanges of electricity between the utilities and solar owners, avoiding either over- or under-charging will become a major issue. Since these exchanges are similar in form to the examples cited earlier, they are especially vulnerable to the problem of over-charging. How do utility accountants know if they are not over-charging, or under-charging, their customers? Given the complicated nature of these new arrangements, if they were not so sure themselves, it would be understandable if the accountants chose to err in favor of their own company. If, under simpler circumstances, utilities have already been involved in overcharging cases requiring billions of pesos in refunds,[67] how much more under these more complicated circumstances?

With the preceding examples in the background, but with the particular context in mind of long-haul deliveries of grid electricity to solar owners some of the time and short-hop deliveries of solar electricity to the electric utility at some other times, let us look at this problem in more detail. The next table summarizes the situation:

Table 34. Accounting for energy delivered in two distinct but inseparable events

A long-haul delivery of mixed electricity		**A short-hop delivery of clean electricity**	
Distant power plants	Solar owner		Neighbors
Source description: The sources are mixed, consisting predominantly of fossil-fueled plants, but including some renewables. The power plants may be hundreds of kilometers away from the load. Delivery of electricity requires high-voltage transmission and distribution lines	**Load description:** Solar owner generates for his own use clear renewable electricity. However, he needs an extra supply from the grid when the sun is down or hidden by clouds, or when he has to operate loads that need more electricity than his solar panels can provide.	**Source description:** Solar owner has an extra supply when the sun is up and his panels generate more electricity than he can use. His supply is usually highest when the sun is overhead, which coincides with the grid's peak period, when the cost of grid electricity is very high.	**Load description:** If the neighbor happens to be using a solar owner's surplus, he is probably within a hundred meters from the owner. Thus, the electricity from the solar owner does not use high-voltage transmission and distribution lines.
Event description: The solar owner is short in supply. So the utility makes a long-haul delivery of mixed electricity from distant power plants to the solar owner. In the process, the utility uses and pays for the use of long-distance high-voltage transmission lines. It also uses its own high-voltage lines, including the low-voltage 220-volt lines for the final delivery to the solar owner. The solar owner incurs a liability for the delivery, equivalent to the kWh delivered multiplied by the retail price of electricity.		**Event description:** The solar owner has a surplus of electricity. Because he is grid-connected, this surplus automatically flows out through the electric meter, to the grid. The surplus replaces some of his consumption. His surplus automatically goes into neighbors (in this analysis, we assume only one) who have some of their lights or appliances switched on. At this point, two simultaneous transactions are occurring, while this transfer of electricity is going on. (See below)	
During a short-hop: The solar owner's surplus is replacing part of the delivery made under the first event, turning what would have been a sale into an exchange transaction between the solar owner and the utility. In the process, the solar owner is extinguishing his liability for the amount that he is replacing.		**During a short-hop:** The solar owner's surplus is being consumed by the neighbor, transferring to the neighbor the liability that he is extinguishing (See left)	

Source: Author

67 Meruenas, Mark. "CA orders Meralco to refund customers ₱5B in overpayments". GMA News Online. Dec. 18, 2014. http://www.gmanetwork.com/news/story/393108/money/ca-orders-meralco-to-refund-customers-p5b-in- overpayments

As rooftop solar becomes more affordable to households and businesses, the problem of accounting for these kinds of grid exchanges will become more and more urgent.

Note that connecting a solar PV system to the grid and sending any solar surplus out does *not* require net metering. Like water, the physics of electricity makes it follow the path of least resistance. When it is generated in-house, the output will be consumed first by the appliances that are switched on. Any surplus that cannot be consumed at that moment will then seek other paths of less resistance—it will in effect *spill out* into the grid. On the grid, still following the path of least resistance, and because longer wires offer more resistance, the surplus will go into the nearest neighbors whose lights or appliances are switched on. This flow of electrons does not care about net metering. The electrons are simply following the physics of electricity.

Can the utility keep track at all of this complex set of deliveries, offsetting replacements, exchanges, second deliveries, and transfers of liability?

It can be done simply, it turns out.

Net metering is the accounting mechanism that keeps track of the kWh throughout this complex set of transactions in a way that accurately accounts for the deliveries, exchanges, and transfers of liability that occur in the process. The mechanism turns out to be extremely simple and immediately implementable without requiring new meters or other equipment, on two conditions: 1) that the meter reading (not just the rotating disc) reverses when the flow of power reverses, and 2) that the electricity going in either direction have a common reference price.

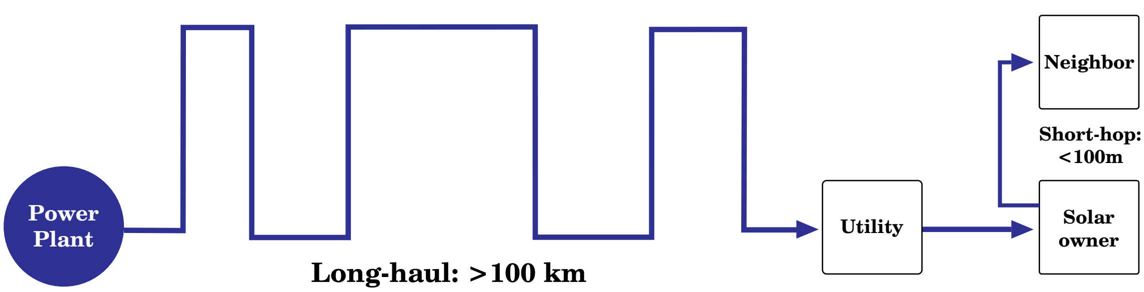
Let us go through the complex set of transactions again, when a solar owner sends his surplus out to the grid, and see how net metering, implemented with the usual bi-directional analog meter and a common reference price, accounts for everything. We will also show how a lower price for the solar owner's surplus results in overcharging.

As explained in Table 34 and shown in Figure 11, the set of transactions consists of two time-separated but inseparable events:

First event: the long-haul

The long-haul delivery. The utility delivers electricity from distant power plants to the solar owner, turning the latter's electric meter forward, after which it is promptly consumed by the latter. This delivery is properly recorded in his electric meter. Part of this delivery is a simple sale of electricity by the utility to the solar owner. Another part, however, will be subsequently replaced by the solar surplus that will flow into the grid.

Figure 11: The two events comprising the set of net metering transactions



Source: Author

Second event: the short-hop

The offsetting replacement. When the solar owner has more electricity than he can use, his solar surplus is automatically ported to the grid. By definition—and by law in the Philippines—net metering allows the consumer to use this surplus to offset an equivalent amount in his consumption. The offset is recorded in the reverse movement of the meter's dials. The extent of the meter's reversal is the measure of both the replacement quantity and the consumed quantity that is being replaced. But for the two quantities to cancel each other out, they must have equal values too. Otherwise, the exchange will not be a fair exchange. The equality of values is a necessary condition for the import and export quantities to cancel each other out, both in kWh and in peso terms, as we proved mathematically in an earlier chapter.

Note very well that this exchange of quantities and values occurs at the boundary between the utility and the customer, which is the electric meter, the two-way connection of the customer to the grid. Identifying this boundary is important because it clarifies the confusion about who owns what.

Behind the meter, everything is owned by the customer. Beyond the meter (from the customer's perspective), everything is owned by the utility. The solar owner of course owns the surplus before he ports it out. But as soon as that solar surplus passes the electric meter, reversing it, that electricity turns into utility property. This answers utility arguments that solar owners "are using utility property without paying for it."[68]

The simultaneous sale to the neighbor. As the solar surplus reverses the first meter on its way out to the grid, it is at the same moment delivered by the utility to the neighbor, who promptly consumes it, a process that is duly recorded in the neighbor's own electric meter. Again, note that it is not the solar owner but the utility, using its own low voltage distribution lines, that *delivers and sells* the now-utility-owned solar surplus to the nearest neighbor.

During this short-hop delivery, it should be easy by now to imagine the offsetting replacement by the solar owner and the sale to the neighbor occurring simultaneously: the replacement reverses the solar owner's meter and, in the same moment, turns forward the neighbor's meter. The simultaneous meter movements in opposite directions duly record the actual replacement by the solar owner and the sale to the neighbor, in the process extinguishing the solar owner's liability to the utility and transferring the liability from the solar owner to the neighbor. Once the solar owner's liability is fully extinguished, it is *as if* the replaced quantity did not enter the solar owner's meter at all. *As if* electricity from a distant power plant just went through some delay along the way and during this delay was miraculously transformed from mixed to clean electricity before it was consumed by the neighbor.

Thus, using only the old bi-directional analog meter, and under net metering and its built-in common reference price, with no need for additional hardware, software or set of accounting procedures, the entire complex set of transactions is fully accounted for.

It is important to remember: the transaction between the solar owner and the utility has become an exchange, not a sale.

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68 Tom Tanton, "Reforming Net Metering: Providing a Bright and Equitable Future," American Legislative Exchange Council, March 2014.

How can double-charging arise?

Any attempt on the utilities' part to change net metering's common reference price to unequal pricing in its favor will result in double-charging, specifically by billing both the solar owner and his neighbor the same long-haul delivery costs.

The mathematics of this double-charging can be shown, as follows:

Let: S_1 = sales income of the utility from the long-haul delivery to the solar owner
S_2 = sales income of the utility from the short-haul delivery to the neighbor
P = retail price of electricity
Q_{IN} = total amount of electricity released by the utility for the transaction
P_{GEN} = the average generation price of electricity
P_{ETC} = all other add-on costs, that is, $P = P_{GEN} + P_{ETC}$
Q_{OUT} = the outgoing amount of electricity sent back by the solar owner to the grid
Q_{NET} = net electric meter reading of the solar owner, that is, $Q_{NET} = Q_{IN} - Q_{OUT}$

The total expected sales income of the utility for the complex set of three-way transactions above is S_1+S_2, and this sum should equal $P \cdot Q$. Calculating the individual S_1 and S_2, we get:

(11) Sales income from solar owner $S1 = (P_{GEN} + P_{ETC}) * (Q_{NET}+Q_{OUT}) - P_{GEN} * Q_{OUT}$

(12) Sales income from neighbor $S_2 = (P_{GEN}+P_{ETC}) \cdot Q_{OUT}$

Combining the two, we get the total sales income of the utility:

(13) $S_1+S_2 = (P_{GEN}+P_{ETC}) \cdot (Q_{NET} + Q_{OUT}) - P_{GEN} \cdot Q_{OUT} + (P_{GEN}+P_{ETC}) \cdot Q_{OUT}$

Simplifying the above equation, we get:

(14) $S_1+S_2 = (P_{GEN}+P_{ETC}) \cdot Q_{NET} + (P_{GEN} + 2 \cdot P_{ETC}) \cdot Q_{OUT}$

The double-charging can be seen as the multiplier 2 in the non-generation charges for the solar surplus Q_R. The long-haul costs were charged not once, but twice—to the solar owner and again to the neighbor, although this cost was incurred only in the long-haul delivery but not in the short-haul delivery.

Even if the cost of the short hop were not negligible, the over-charging will not disappear. Because the short hop uses none of the high-voltage transmission lines or the distribution transformers, it will not register on the metering equipment monitoring their use. Ignoring tower and transformer costs, transmission line costs are usually measured in pesos per kilometer. So roughly, one-thousandth the distance, one-thousandth the cost. The cost of a short, 100-meter hop—to use some typical numbers—will definitely be lower than the cost of a long 100-km haul.

The equation can be further rewritten as follows:

(15) $S_1+S_2 = P \cdot Q + P_{ETC} \cdot Q_R$

In this form, the double-charging also shows itself as an unearned extra income, $P_{ETC} \cdot Q_R$, over the expected income $P \cdot Q$.

What about under-charging?

Let us use the same definitions as above for our variables:
S_1 = sales income of the utility from the long-haul delivery to the solar owner
S_2 = sales income of the utility from the short-haul delivery to the neighbor
P = retail price of electricity
Q_{IN} = total amount of electricity released by the utility for the transaction
P_{GEN} = the average generation price of electricity
P_{ETC} = all other add-on costs, that is, $P = P_{GEN} + P_{ETC}$
Q_{OUT} = the outgoing amount of electricity sent back by the solar owner to the grid
Q_{NET} = net electric meter reading of the solar owner, that is, $Q_{NET} = Q_{IN} - Q_{OUT}$

When utilities receive a specific quantity of electricity, say Q_{OUT}, from power plants, they expect to earn $P \cdot Q_{OUT}$ from this amount of electricity, P being its retail price. Under net metering, it appears, they will only be earning a lower $P \cdot Q_{NET}$. Many may believe this claim, unless they saw beyond the incomplete picture that the utilities present. The full picture includes the long-haul delivery to the solar owner, and the short-hop delivery to the neighbor who consumes the solar owner's contribution to the grid and is also charged by the utility for this.

Going back to the equation for the utility's total sales income, let us change the solar owner's credit from $P_{GEN} \cdot Q_{OUT}$ to $P \cdot Q_{OUT}$ to enforce a common reference price, and check if any under-charging occurs:

(16) Sales income from solar owner $S1 = (P_{GEN} + P_{ETC}) * (Q_{NET} + Q_{OUT}) - P * Q_{OUT}$

Simplifying the above equation, we get:

(17) $S_1 + S_2 = (P_{GEN} + P_{ETC}) \cdot Q_{NET} + (P_{GEN} + P_{ETC}) \cdot Q_{OUT}$

Compare Equation (17) above to Equation (14) in the double-charging case. The multiplier 2 in the non-generation charges for the solar surplus Q_R has disappeared. The double-charging is gone.

The equation simplifies to:

(18) $S_1 + S_2 = P \cdot Q$

The utility gets its expected total sales income. There is neither over-charging nor under-charging.

This chapter has shown that net metering is the perfect mechanism for keeping track of the complex set of transactions that happen when millions of consumers start producing their own electricity and exchanging kilowatt-hours with the utility. It is very simple to implement and results in neither over- nor under-charging. Thus, net metering can play a long-term role not only in the ongoing energy transition to renewables but also in the more distant future when cheap solar will enable practically every household and rooftop owner to generate their own electricity, although they will still find themselves short some of the time and with a surplus at some other time.

The next chapter will deal with some of the electric utility arguments against net metering.

Chapter 11
Electric utility arguments against net metering

Electric utilities dislike net metering's common reference price, which assigns the same price to incoming and outgoing power. They want to assign a lower price to net-metered home-generated solar power, and a higher price to power they deliver to homes.

Edison Electric Institute (EEI), which "represents all U.S. investor-owned electric utilities,"[69] uses the following argument:[70]

> *"Because of the way that net metering policies originally were designed, net-metered customers often are credited for the power they sell to electric companies, usually at the full retail electricity rate, even though it would cost less for the companies to produce the electricity themselves or to buy the power on the wholesale market from other electricity providers.*
>
> *"Many energy experts agree that net-metered customers should be compensated at the wholesale price for the electricity they produce, similar to other electricity providers. This reflects the fact that electric companies buying this power still must incur the costs of delivering the power to their customers, including the costs of maintaining the poles, wires, meters, and other infrastructures required to deliver a reliable supply of electricity."*

Thus, EEI argues, net-metered customers should be credited only for the wholesale price (what we call in the Philippines the average generation charge or the "blended cost" of electricity), not the retail price of electricity. Net-metered customers, EEI insists, must still pay for the "cost of transporting and delivering the electricity through the electric grid to reach a customer."[71]

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69 http://www.eei.org/ about/members/Pages/default.aspx

70 Edison Electric Institute, "Straight Talk About Net Metering." http://www.eei.org/issuesandpolicy/generation/ NetMetering/Documents/Straight%20Talk%20About%20Net%20Metering.pdf, p. 2-3.

71 Ibid.

The simple answer to the EEI argument is that the liability for these transport and delivery costs have been transferred to the neighbors who used the exported surplus, because this surplus registered on their meters. Thus, all the costs which EEI claims are being avoided by their net-metered customers are actually being paid by other customers who used the surplus.

If this seems confusing, then let us consider an analogy.

Let us say that you ordered from an LPG supplier three filled tanks worth ₱550.00 each. But since the nearest supplier is several hundred kilometers away, the delivery and other charges per tank (like VAT, provision for losses, etc. is ₱600.00 (These hypothetical numbers mirror Meralco's generation charge of around ₱5.50 per kWh and the ₱6.00 per kWh charge for "delivering" the electricity.)

In the meantime, however, you have built a small household-scale biogas system that enables you to save 1/3 of your LPG consumption.

When the LPG tanks are delivered at your door step, you inform the delivery boy that you will return one tank and will only pay for two. However, you also tell him that you have made arrangements with your neighbor, who is willing to pay at the usual rate of ₱550.00 plus ₱600.00 for the LPG tank you are returning. You explain to the delivery boy that he still delivers the same three tanks, and he will still take home the same expected payment per tank of ₱1,150.00 (₱550.00 + ₱600.00).

Unsure, the delivery boy calls his bosses. They agree to let your neighbor pay for the third tank, but instruct him to charge you ₱600.00 for the delivery charges. They argue that they have already incurred various expenses in delivering the third tank to you, and therefore they can only cancel ₱550.00, the value of the tank's contents. They insist that you should pay them the delivery and other charges, worth ₱600.00 in all.

You refuse, of course. You argue that the third tank will be fully paid for by your neighbor, contents plus the delivery and other charges. Thus, if the LPG supplier also insists on charging you for the delivery of the third tank, they will be double-charging. The best proof of this, you argue, is that the delivery boy now expects to bring back for the third tank, your neighbor's ₱1,150.00 payment, plus your ₱600.00, a clear case of double-charging of delivery charges.

You bring your dispute to the government. Will the government decide in your favor or in favor of the LPG supplier?

This dispute reflects exactly the debate around net metering and what electric utilities want. When you generate surplus electricity from your solar panels and export them to the grid, this exported surplus is used by your neighbors and will register in their meters. Thus, when your neighbors pay the utility their electric bills, their payment covers the part of your surplus, which they used. As usual, both the generation charge and the "delivery" and other charges will appear on their electric bills. In short, the kWh you returned to the grid is fully paid for by your neighbors, who paid for both generation and "delivery" charges.

Returning to our analogy, the owner of the backyard biogas digester returns one of the three tanks he ordered, pays only for two, and asks his neighbor to pay for the third instead. The neighbor, accepting this transfer of liability, agrees to pay for the tank as well as its delivery charge. So everything is fully paid for.

EEI, on the other hand, wants to credit the customer who returned the third tank only the cost of the tank's contents, and to bill him—and the neighbor as well—the delivery charge for the same tank. The EEI position will in fact result in *double-charging*. If you want to be polite, call it a *hidden subsidy*.

Another vocal critic of net metering is the American Legislative Exchange Council. ALEC uses an interesting analogy to support its position against net metering:[72]

> *"Imagine you have a home vegetable garden and have had a very good year and a bumper crop of tomatoes. Do you consider it somehow appropriate for you to send those tomatoes down your local grocery store and expect to sell them to the grocer at the same price that he sells to the public? How would that help him pay his rent, and maintenance and heating bills for the store? The taxpayer has already paid you to grow tomatoes. Why, you have even made the grocer pay to have the tomatoes carried from your house to his store. Won't this arrangement raise the cost of tomatoes and other groceries to other shoppers? Well, that's exactly what net metering does. It forces the grocer—the utility—to buy a wholesale product at retail prices."*

The ALEC analogy is faulty because it is incomplete. A full analogy would involve you ordering, say, 30 kilos of tomatoes from your grocer (which your grocer perhaps imported out of state), delivered to your doorstep, for which the grocer charges you the retail price that covers all the grocer's costs, including the transport of the tomatoes from another state to the grocer, plus of course the cost of home delivery, the grocer's profits, government taxes and so on. As the ALEC analogy says, you have a bumper crop of tomatoes. So you accept only 20 kilos of the delivered tomatoes. But your next-door neighbor, who also wants tomatoes, agrees to get the other 10 kilos. So your grocer's delivery service brings the 10 kilos to your neighbor instead, which your neighbor pays for in full. As for the 20 kilos which were delivered to you, you also paid for them of course—in full. Clearly, the grocer was in fact fully paid for his 30 kilos of tomatoes.

ALEC is arguing that your refund should only cover the wholesale price; you should still pay for inter-state transport, delivery charges to your home, the grocer's profit, and government taxes for the 10 kilos you returned, although your next-door neighbor already paid for them. ALEC is trying to justify the double-charging that is currently being inflicted by U.S. utilities on non-net-metered solar PV owners, who are sending their surplus to the grid to be used by their neighbors but are getting credit only for the wholesale cost of electricity.

Whether it involves electricity, tomatoes or LPG, crediting only the wholesale and not the full retail price of returned items that were absorbed and fully paid for by neighbors is double-charging. If you are at the grocery checkout counter, and you decide to return an item you just paid for, and which the next person on the line agrees to buy for its full price, you have the right to demand a full refund.

ALEC further claims that net metering advocates "miss the fact that they are using utility property without paying for it." ALEC is apparently referring to the fact that the net-metered surplus passes through utility-owned posts and wires on its way to the neighbor.

Our reply: The boundary between utility and customer property is the electric meter. It is the equivalent of the grocer's checkout counter. Electricity that travels on the utility's distribution lines is a property of the utility. As soon as it passes the customer's electric

72 Tanton, p. i.

meter, turning it forward, the electricity becomes customer property. Similarly, as soon as the net-metered customer's solar surplus passes his electric meter and reverses it on the way out, that surplus becomes utility property. The ownership change occurs at the electric meter, like the ownership change that occurs at the checkout counter. ALEC is wrong to claim that solar rooftop owners “are using utility property without paying for it.” It is the utility, as the new owner of the solar surplus, which uses its own posts and wires to deliver the surplus to the next-door neighbor. And since this surplus will register on the neighbor's meter, the utility will get fully paid to the last cent for this delivery service.

Finally, for the sake of argument, let us accept the utilities' perspective that net metering is not an exchange as we have argued, but a double-sale: power going into the net-metered customer is one sale, and the solar surplus exported by the same customer is another sale. The utilities argue that these two should *not* count as a single transaction involving a simple transfer of liability, like returning an item that is then paid for by another customer, but should be treated as two completely separate transactions.

Let us accept that the electricity consumed by a customer can be treated and metered separately from his solar surplus that he exports to the grid. In such a case (which is contrary to Philippine law), utilities are now in a position to price exported surpluses separately from regular electric meter readings. The utility bills the solar customer the full retail price of his consumption. When the customer subsequently exports his surplus to the grid, the utility then delivers this surplus, which it now owns, to the neighbor(s), and bills the neighbor(s) the same full retail price for the exported surplus.

The question now is: what value should be assigned to that solar surplus? How should it be priced? EEI, ALEC and their allies are proposing to price it below retail. They want to deduct the cost of transmission, distribution, etc. and keep these for themselves, and then credit the exporter of the surplus for what remains, what they call the “wholesale price” of electricity. Very roughly, this means half of the retail price will go to them, and half to the exporter of the surplus.

What is wrong with this scenario? At least two things:

1. Let us trace once more the path of the electricity consumed by utility customers. At the generating plant, this chunk of electricity passes through transformers as it is stepped up in voltage and sent through the transmission company's very-high-voltage transmission lines. At the end of the final transmission line, the chunk passes through more transformers to make it more suitable for the DU's high-voltage distribution lines. Eventually, the chunk is stepped down further in voltage and until it is suitable for the DU's low-voltage lines that serve residential and commercial neighborhoods. This chunk registers as a forward movement on the meters of the generating plant, the transmission company and the distribution utility. Throughout this process, the chunk accumulates additional fees and charges representing the added-value of the transformers and the hundreds of kilometers of those transmission and distribution lines. Finally, as it goes into the customer's electric meter, the chunk would have accumulated all the additional charges, raising its value to the retail price of electricity.

When the sun is high in the sky, on cloudless days, the utility customer with a solar rooftop generates a surplus that goes out to the grid. Under net metering, the outgoing surplus will simply reverse the customer's meter. But the utilities want any outgoing surplus metered separately so that they can assign a lower price to it. As soon as it passes this second meter, the solar surplus is on the grid, and becomes a property of the utility.

Electricity follows the path of least resistance. The shorter the wire, the less the resistance. Thus this surplus is delivered from the net-metered customer to his nearest neighbors who have some appliances turned on, a distance in the order of a hundred meters or less. (We will assume one neighbor only, for simplicity.) This neighbor-to-neighbor transfer of surplus *avoids* the cost of moving electricity from the generating plants to consumers, a distance in the order of hundreds of kilometers. It avoids the cost of going through high-voltage transmission and distribution lines, transformers, and their associated supervisory control and data acquisition systems. One-thousandth the distance roughly means one- thousandth the cost. Thus we can say that the cost of this neighbor-to-neighbor transfer, like returning an item and asking a delivery service to bring the item to a next-door neighbor who will pay for it instead, is *negligible*. It is *too cheap to matter*. Yet, the electric utility wants to charge the neighbor the full delivery fee for this chunk, as if it had delivered the surplus from a distant power plant, through the transmission company's high-voltage lines, through the utility's distribution lines and transformers, to the neighbor.

The cost of that neighbor-to-neighbor transfer is “negligible”, but it is not zero. So, not charging for it is still a loss to the utility, isn't it? Far from it. Rather than recover this negligible amount from the neighbor, the utility actually has better options. First, there are carbon markets which are bound to grow as global warming and climate change take their inevitable toll. Distributing carbon-free electricity commands value in these markets. Also, most utilities are required to distribute some renewable electricity, under what are usually called renewable portfolio standards (RPS). Utilities may be subject to fines if they don't meet their RPS obligations. Utilities that are over-quota can sell their surplus to those that are under-quota. Hence, moving a net-metered customer's surplus to a neighbor is again worth money to utilities. In fact, in a market where prices will be set by much larger chunks of renewable electricity distributed on the grid over hundreds of kilometers from wind and solar farms, it will be worth much more than its actual cost.

Should the utilities then spare the neighbor of these transmission, distribution and other charges and charge him only the generation cost of electricity? If they did, it would be a windfall to the neighbor, who is expecting—and willing—to pay the full retail price for his meter reading.

We argue that this added-value belongs neither to the utility nor to the neighbor.

Who took the risk and invested the money to generate renewable electricity at the point of use, bypassing the expensive transmission and distribution system of the grid? Who displaced the chunk of conventional electricity with solar electricity, resulting in less greenhouse gases, less energy insecurity, less local pollution and less displacement of local communities? Who avoided electricity from expensive peaking plants, thereby bringing the average cost of electricity down? For these things, we have the solar owners (and other RE-adopters) to thank for. They created all these added values; they should get the credit for the neighbor's potential windfall.

2. Let us now consider the actual value of the solar surplus itself. The EEI/ALEC position values it at roughly the same rate as the average generation price, about half the retail price, the utilities pocketing the balance. Yet, utilities themselves pay a range of prices for other types of electricity that they buy. During peak hours, they regularly pay *higher than retail* for electricity coming from oil- or natural gas-fired plants, *not* the retail price minus delivery and other charges. Solar surpluses typically occur when the sun is shining brightly high in the sky, when demand for electricity is high and utilities buy electricity from peaking plants at prices higher than the retail price. This peak-hour price is what utilities usually avoid whenthey are taking surpluses from solar rooftops. If solar surpluses are to be paid the avoided price of electricity, should not solar surpluses be paid higher than retail rates too?

In fact in many countries that implemented feed-in-tariffs in the past, solar electricity (and other clean renewables) *were* bought at higher than retail prices, because their societies valued these types of electricity more: they didn't cause health problems, displace communities, poison the environment, warm the globe and change the climate, deplete non-renewable resources, and so on. They also created more jobs, relied on local resources, enhanced energy security, eased regional and global tensions around contested oil reserves, and did not cause nuclear proliferation. The debate instead in these countries was: how much higher than the retail price did clean renewables deserve?

Thus, adopting a common reference price for incoming and outgoing power (i.e. parity pricing) is already a compromise between, on one hand, those who believe renewables should be valued higher than retail as some feed-in-tariff implementations did and, on the other hand, those who think they should be priced lower than retail as many utilities insist.

Anti-net metering lobbyists do not want a compromise. They want their unreasonably extreme position to prevail. To make this happen, they have been calling parity pricing a "subsidy" for renewables. We have already explained earlier why this is not a subsidy at all: crediting the net-metered customer the full retail price for his surplus is no different from crediting a customer at a grocery checkout counter the full retail price for an item he is returning, knowing that the next customer on the line is willing to pay for it, also at the full retail price.

Let us now face the issue of subsidies squarely. We have shown that parity pricing under net metering is no subsidy. This does not mean that we do not want subsidies for renewables. Not all subsidies are bad. Subsidies are a valid option for governments to encourage things to move in a desired direction, or to support important efforts that cannot otherwise take off the ground or cannot do so fast enough. Subsidies to renewables belong to this category. Renewables will help improve our energy security especially under worst-case scenarios like peak oil. Renewables also reduce pollution and mitigate climate change. Solar panels on rooftops do not displace communities, poison them, or cause nuclear proliferation.

Historically in the energy sector, however, the biggest subsidies have been enjoyed by the nuclear and fossil-fuel industries. G20 governments, for instance, continue to subsidize fossil-fuel exploration to the tune of $88 billion per year, more than twice what the top 20 private companies are spending.[73] A report of the U.S. Energy Information Administration released on March 12, 2015 shows that in 2013, the electricity sectors which received direct subsidies from the federal government included: fossil-fuel ($4.1 billion); nuclear ($1.7 billion); transmission and distribution ($1.2 billion); solar ($5.3 billion); wind ($5.9 billion).[74] The U.S. EIA emphasizes that their report does not include all subsidies. In addition to money from governments, producers of dirty electricity enjoy hidden subsidies too. By externalizing large parts of their costs, fossil-fuel-based generating plants (and think-tanks that they fund) enjoy enormous hidden subsidies that are eventually paid for by local communities and the general public in the form of health costs, social costs, environmental costs and costs from climate-related disasters. The utilities' demand for impact studies, one-time "net-metering" charges, recurring "meter-reading" charges, etc. from their net-metered customers are not only artificial barriers against distributed renewables. They are also hidden subsidies for the utilities themselves.

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73 Roberto Savio, "Climate Change Continues, Impervious to Official Declarations", *Other News*, March 19, 2015.

74 U.S. Energy Information Administration, "Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2013", March 12, 2015. http://www.eia.gov/analysis/requests/subsidy/.

In summary, under the scenario implementing what the utilities want, they will be overcharging the neighbor with imaginary transmission and distribution costs which were never incurred. They will also be underpaying net-metered customers for their high-value surplus. The result: hidden subsidies for the utilities.

The various costs can be more properly assigned and fairly calculated of course. But this will then complicate things a lot, requiring additional metering equipment and major changes in billing and accounting procedures. In the end, we will end up with something that is very much like a full transfer of liability from the owner of the solar surplus to his neighbor. And this can be implemented very simply if we accept for billing purposes the readings from meters that reverse when power flows in the opposite direction. In short, we will end up with something very much like net metering.

In the meantime, utilities should stop putting all kinds of artificial barriers to net metering—a scheme so simple and costless that even low-income families can join it, especially as solar PV prices drop further.

This hypothetical case is the final test whether net metering causes losses to the utility or not: Someone runs a diesel-fuelled synchronous generator (one that can sync with the grid). Due to an accidental connection, it ends up sending out 50 kWh into the grid, reversing the careless owner's meter by 50 kWh. The 50 kWh go into a neighbor whose appliances are on, turning the latter's meter forward by the same amount. The neighbor pays for the 50 kWh added to his meter.

Here is the test: Is anyone due any other payment? Specifically, did the accident cause the utility to subsidize the careless owner? Perhaps some unpaid transmission, distribution and other costs associated with 50 kWh of electricity?

Let us check everyone's perspective. The neighbor's perspective: He paid for 50 kWh which he actually consumed as reflected in his meter reading. So he has no problem. The neighbor's payment, however, goes not to the careless generator owner who actually supplied the 50 kWh, but to the utility whose 50 kWh was erased from the meter. The utility's perspective: The neighbor's payment fully covers the lost income from the 50 kWh that the careless customer had already consumed but accidentally erased from his meter. So the utility should have no problem either. The careless owner's perspective: Diesel is expensive. The retail price of the 50 kWh he extinguished when he reversed his meter is less than the cost of electricity from a diesel generator, so he is not happy with the accident. It is clear, however, that he got no subsidy from the utility when he reversed his meter. He owes nothing to the utility or to his neighbor. A utility claim to recover the accidental "subsidy" would be spurious and will not prosper.

When you come to think of it, whether the export of 50 kWh was accidental or not is in fact irrelevant. If the careless owner intentionally generated more surplus and sent it out to the grid, we can go through the analysis once more, and the result will be the same: he would not owe anything to the utility or his neighbor. He would be losing money of course, but this is his own business, not the utility's. However, if the cost of electricity from the generator were cheaper than retail (as it would be if he used rooftop solar panels), he would be saving money. Then he would want to do it again and again.

Thus, net metering encourages more private investments in solar panels and other low-cost renewables, without requiring subsidies from the government or from the utility.

The most accurate way to describe net metering without analogies is that it is a complicated set of three simultaneous transactions that occur when a solar owner exports his surplus: 1) an exchange of kilowatt-hours between the utility and the solar owner, 2) a transfer of liability from the solar owner to a neighbor, and 3) a sale of kilowatt-hours by the utility to the neighbor. These three simultaneous transactions make net metering hard for some people to understand, and therefore easy for the utilities to obfuscate. A single reversing meter fully accounts for all the transfers of values that occur under these three transactions, making net metering very simple to implement.

The anti-net-metering Institute for Electric Innovation (IEI) makes a big case out of their finding that an increasing number of solar rooftops are being leased. Because of this, IEI says, the delivery charges that they want to credit to the utilities are going mostly to solar leasing companies.[75]

IEI has inadvertently revealed the true problem with private utilities. It is called *envy*. The utilities are envious that money which can be going to them are now going to solar leasing companies instead. They are envious that renewables now seem to get more subsidies than they get. The solution is in fact simple: the utilities can also invest in solar, compete with solar leasing companies and themselves offer similar services to their customers. Consumers can then decide, in true market fashion, whether to lease from the utility or from any of the competing solar leasing companies.

Utilities have been treating customers as captive clients who have no choice but to passively obey whatever terms the utilities dictate, just like mainframe computer and landline operators did in the past. They are so used to treating customers this way that under net metering, they get a persistent feeling that they are "losing" something. Of course they are, but it is not something they are entitled to. They are losing the competition in a freer market; they are losing market share.

Generating one's own power is part of the great do-it-yourself movement that motivates fiercely independent individuals, families and communities. Low-cost solar panels on rooftops and small-scale wind turbines are permanently changing the rules of the game. Users of electricity can now empower themselves, in more ways than one. Utilities cannot stop them anymore. Like operators of mainframes and landlines, utility operators must learn to adjust to the new reality and accept their reduced role in the future: at night, or when there is not enough sun or wind, or when there is too much sun or wind.

When they go to the government whining that they should be compensated for their "losses" under net metering, they are basically asking for more subsidies.

One more argument against net metering needs to be tackled: solar owners are in effect using the grid as a giant battery. They should pay for using the grid for energy storage. It is true that solar owners are using the grid as their battery, thereby avoiding the need to purchase their own. But the same can be said of the electric utility: they are in effect also using solar owners for storage. When the utility takes electricity from the solar owner noontime, thereby avoiding the need to purchase expensive power from peaking plants, and then offset this with electricity sent to the solar owner at night, the utility also uses the solar owner for storage. Thus, there is mutual benefit in the exchange, justifying the offsetting mechanism.

This chapter dealt with various utility arguments against net metering. The next chapter will discuss how net metering has been implemented in the Philippines.

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75 Institute for Electric Innovation, "Net Energy Metering: Subsidy Issues and Regulatory Solutions" (Issue Brief), September 2014, p. 4.

Chapter 12
The Philippines today has net billing, not net metering

In the Philippines, net metering was introduced through the Renewable Energy Act of 2008, signed December of that year. The Act defines "net-metering" (most other countries spell it without the hyphen) as:

> "... a system, appropriate for distributed generation, in which a distribution grid user has a two-way connection to the grid and <u>is only charged for his net electricity consumption and is credited for any overall contribution to the electricity grid</u>." (Chap. I, Sec. 4, underscoring by the author)

As can be seen above, Philippine law is clear that the user should *only* be charged for his net electricity consumption. This net consumption is further defined as the user's total consumption minus his credits. Remember that the credits refer to kWh, not pesos. The "two-way connection to the grid" may be interpreted as the common bi-directional electric meter that connects the user to the grid.

The law's definition above is echoed word-for-word in the Act's Implementing Rules and Regulations (IRR), adopted by the DOE the following year, and is further elaborated on, as follows:

> "Net-metering is a consumer-based renewable energy incentive scheme, wherein electric power generated by an eligible on-site RE generating facility and delivered to the local distribution grid may be <u>used to offset electric energy provided by the DU</u> to the end-users during the applicable period." (Sec. 7, IRR, underscoring by the author).

This elaboration by the IRR further clarifies that the energy contributed by the user and credited to him may be used to offset electricity earlier delivered by the utility. The offsetting arrangement makes it *an exchange, not a sale*.

In clarifying what "net electricity consumption" meant, the country's Energy Regulatory Commission (ERC) was even more explicit in its "Rules Enabling the Net-Metering Program for Renewable Energy" adopted in May 2013.[76] It defined net-metering as:

> "a system, appropriate for distributed generation, in which a distribution grid user has a two-way connection to the grid and is <u>only charged or credited, as the case may be, the difference between its import energy and export energy</u>". (Art. I, Sec. 4, ERC Enabling Rules, underscoring by the author)

The ERC enabling rules also defined "import energy" as "the energy imported or received by the Qualified End-user to the Grid/Distribution System" and "export energy" as "the energy exported or delivered by the Qualified End-user to the Grid/Distribution System".[77] (Art. I, Sec. 4)

In fact, "being charged only for the net consumption" and getting credit for one's energy contribution to the grid are different ways of saying the same thing: the former in peso terms, the latter in kWh terms. If the credited kWh surplus cancels out a portion of the total kWh consumption, then obviously only the net consumption can be charged.

What is less obvious is that when only the net consumption is to be charged, as the law specifies, the offsetting process cancels out price considerations for the exchanged amounts. When one borrows a kilo of rice from a neighbor and returns a kilo the next day, there is no pricing issue involved.

For one to offset the other, the same reference price must apply to both sides of the exchange, and price considerations intrude only with the net of the exchange. A common reference price is a necessary condition for the mechanism to work. It turns the two transactions—an export and an equivalent import—into a fair exchange not only of equal quantities but also of equal values of electricity.

This is also how net metering is in fact implemented in the U.S. where it originated, and in other parts of the world. Without a common reference price, any mechanism that calls itself "net metering"—with or without the hyphen—is actually pseudo-net-metering.

ERC also set a preliminary reference price" for the exchange of energy

In the same ERC enabling rules cited above, under the heading "Pricing Methodology", the ERC also set a "preliminary reference price in net-metering agreements", as follows:

> "In case of DUs with special programs, the applicable preliminary reference price shall be the generation charge it imposes on its regular captive market, which is based on its blended generation cost excluding other generation adjustments." (Art. IV, Sec. 12)

This extension, which is neither in the law nor the IRR, will contradict the RE Act and the ERC's own definition of net metering, if the ERC "reference price" is interpreted to mean the price of the outgoing energy only.

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76 http://www.erc.gov.ph/Files/Render/media/RulesEnablingTheNet-MeteringProgramForRenewable Energy.pdf

77 To emphasize the non-monetary nature of this exchange, this paper prefers the noun/verb "port" instead of import and export. In computing hardware lingo, a port is an interface through which data passes in or out. In software, to port means to transfer software from one operating system to another. The term reflects better the non-monetary nature of exchanges occurring under net metering.

But it may still comply with the country's RE Act, if the reference price is interpreted as the price governing the exchange as a whole; that is, the price of both incoming and outgoing energy, which cancel each other out as the various definitions clearly mean, but whose monetary value may need to be recorded for accounting purposes.

In fact, there is nothing in the ERC definition that says that the reference price applies only to the outgoing but not to the incoming energy. It will actually settle the debate once and for all, if the ERC meant a common reference price for the exchanged quantities for accounting purposes, in special cases where a monetary value has to be assigned to the exchange of energy. The ERC's conditional term, “in the case of DUs with special programs”, also supports this interpretation.

This would be similar to other peering arrangements where transactions in opposite directions cancel each other out, and therefore do not have to involve a price, but may be assigned a reference price for accounting purposes.

Examples of such arrangements would include banks who borrow foreign exchange from each other, Internet hubs operated by different commercial entities who send and receive gigabits of data between each other, competing mobile phone providers who must account for incoming and outgoing connections among themselves, neighboring product suppliers who regularly borrow items from each other whenever they run out of inventory, and so on. In all these peering arrangements, essentially the same words and spirit of the RE Act apply: the exchange of equal quantities of energy, dollars, gigabits of data, minutes of talk-time, retail items, etc. offset each other and cancel each other out, presuming a common reference price; but the exchanges may specify a reference price for accounting purposes. We repeat for emphasis: these are exchanges, not sales.

This is a major conclusion: *nowhere in the RE Law, the IRR or the ERC enabling rules on net-metering are the electric utilities authorized to charge for the energy they deliver at a price that is different from the price of energy they take from their net-metering customers.* The law, in fact, explicitly states that the user is “credited for any overall contribution to the electricity grid” and is “only charged for his net electricity consumption”, which automatically means a common reference price.

As we show in this book, *the arguments in favor of a common reference price for a net-metered exchange are iron-clad.*

It is also important to emphasize that net metering and the other examples above are an exchange, not a sale. The reader must always keep this in mind, when analyzing net metering: *it is an exchange, not a sale*.

Translating the legal provisions into mathematical form

We will now translate into mathematical form the Philippine legal provision on net metering that we explained earlier.

We ask the readers' indulgence: do not be intimidated by the equations. We will guide you through them. Once you understand the simple equations, it should become starkly clear that net metering requires a common reference price for both incoming and outgoing energy.

First, let us review the legal provisions.

- **The Renewable Energy Act (RA 9513) says:** The net-metering customer “<u>is only charged for his net electricity consumption</u> and is credited for any overall contribution to the electricity grid”. [Sec. 4 (gg)]

- **The Act's Implementing Rules and Regulations echo this definition:** The net-metering customer "is only charged for his net electricity consumption and is credited for any overall contribution to the electricity grid." [Sec. 3 (kk)]

- **The IRR clarifies the definition further:** "...electric power generated by an end-user … may be used to offset electric energy provided by the DU to the end-user during the applicable period." [Sec. 7]

- **The Energy Regulatory Commission's Rules also echo the law and its IRR:** The net-metering customer "is only charged or credited, as the case may be, the difference between its import energy and export energy." [Sec. 4 (n)]

In short, RA 9513, its IRR, and the ERC net-metering rules are all talking about an exchange of energy, one offsetting the other, and that the user should only be charged the difference between import and export, which is the net of the energy exchange.

To avoid any potential misunderstanding, let us write the charge allowed by the RE Act, Section 4 (gg) as a mathematical expression:

Charge allowed by law = P*Qnet

where P is the retail price of electricity and Qnet is the net electricity consumption. This net electricity consumption which, in turn, is explicitly defined in the ERC rules on net metering, Section 4 (n), can be written as:

Qnet = Qin – Qout

where Qin is the total quantity of energy (in kWh) imported by the net-metering customer, and Qout is the total quantity of energy (in kWh) exported by the net-metering customer.

Therefore, we can also write the charge allowed by law as:

P*Qnet = P*(Qin – Qout)

Expanding the above equation, we get: P*Qnet = P*Qin – P*Qout

Note that P*Qin is the peso value of the total energy import by the net-metering customer, and P*Qout is the peso value of the total energy export by the customer. Both imported and exported energy automatically have a common reference price.

For emphasis, let us reiterate the conclusion of this chapter: *the net metering provisions in Philippine laws and regulations require a common reference price. This common reference price mathematically follows from the definition of net-metering in the RE Law, its IRR and the ERC Rules.*

This is all consistent with how net metering is also implemented in the U.S. and in other countries.

Unfortunately, Philippine homeowners today who invest in a solar rooftop system and request a net metering connection with their electric utility as provided by law are instead put under a different scheme called "net billing". Instead of offsetting kilowatt-hours, they first convert the kWh exchanged into monetary values before charging the solar owner the net. But here's the catch: the utilities price the electricity that the solar owner imports at the retail price, but price the electricity that the solar owner exports at the much lower average generation cost.

Net metering was a major advance from earlier arrangements where the utility set a much lower price for electricity sold to them by consumers, compared to the price of electricity they sold to consumers.

These earlier arrangements were a form of net billing, which account for the give-and-take of electricity not in energy terms (kWh) but in monetary terms (dollars or pesos). This usually required two sets of meters, one for the incoming electricity, and another for the outgoing electricity. The incoming and outgoing charges are calculated from the meter readings. If the balance is in favor of the RE producer, it is usually carried forward to the next month. If it is in favor of the utility, the RE producer is usually obliged to settle the balance every month, as usual.

Under net metering, the old electric meter was enough. The meter runs forward when the utility is supplying electricity to the consumer. It runs backward when the consumer is sending his surplus production to the grid. A net balance in favor of the user is usually carried forward to the next month, while a balance in favor of the utility must be settled at the end of the month as usual. In or out, the price of electricity is considered the same.

The greatest advantage of net metering was its simplicity, both in concept and in implementation. The solar panels were connected into the inverter's input. And the inverter simply plugged into a wall socket. No new metering equipment was needed. No change in accounting or billing procedures was needed. Electric meters *did* run backwards when power went the opposite direction.[78] The RE pioneers found that amazing. If their systems were large enough, they could actually end up with a zero balance, or even a balance in their favor, at the end of the year.

Or when you go on a summer vacation and you turn off all your appliances, practically all your solar PV output can go to the utility while you are away, earning you a huge credit that you can use for the next several months.

Utilities do not like net metering, for obvious reasons. They think consumers should be paying utilities, not the other way around. Luckily for consumers, the Renewable Energy Act of 2008 (RA 9513) requires utilities to implement net metering, as long as the size of a solar PV system is less than 100 kWp.

The greatest advantage of net metering is its simplicity both in concept and in implementation

The utilities' version of net metering is elaborated in "Net Metering Reference Guide: How to avail solar roof tops and other renewables below 100 KW in the Philippines".[79] This guide is not based on parity pricing. Contrary to law, it allows distribution utilities to pay lower for consumer-produced electricity, but charge higher for utility-produced electricity. In other countries, this is called "net billing," not net metering.

Under the utilities' implementation, the simplicity, the pro-RE impact and other benefits of true net metering have been lost.

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78 For a video of a solar installation making a Meralco meter run backwards, see http:www.amaterasolar.com/demo-video.

79 http://www.doe.gov.ph/netmeteringguide/

DOE's definition of net metering was written by Atty. Ranulfo Ocampo, president of the Private Electricity Power Operators Association (PEPOA) and chairman of the NREB Sub-Committee on Net-Metering. So, it was a distribution utility (DU) representative who defined net metering for DOE. Under "How Net Metering Works: Understanding the Basics of Policy, Regulation and Standards," in answer to the question "What is Net-Metering," Atty. Ocampo writes:[80]

> "Net-metering allows customers of Distribution Utilities (DUs) to install an on-site Renewable Energy (RE) facility not exceeding 100 kilowatts (kW) in capacity so they can generate electricity for their own use. Any electricity generated that is not consumed by the customer is automatically exported to the DU's distribution system. The DU then gives a peso credit for the excess electricity received equivalent to the DU's blended generation cost, excluding other generation adjustments, and deducts the credits earned to the customer's electric bill."

This new definition states that a DU "gives a peso credit for excess electricity received equivalent to the DU's blended generation cost..." The definition clearly prices the exported electricity (which is presumably renewable, because net metering is being discussed here in the context of the Renewable Energy Act) at the utility's "blended generation cost". This would be the generation charge that appears in a Meralco bill, for instance. This generation charge is much lower than the retail price of electricity, which the utility charges the consumer. In Metro Manila today, the general charge hovers around 5.50 while the retail price of electricity is around ₱11.50.

Where did the DOE get its definition of "net-metering?" The DOE guide's author quotes the Wikipedia:

> "Net metering is an electricity policy for consumers who own renewable energy facilities (such as . . . solar power) which allows them to use electricity whenever needed while contributing their production to the grid."

Here is the Wikipedia definition, quoted in full:

> "**Net metering** is a service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and delivered to the local distribution facilities may be used to offset electric energy provided by the electric utility to the electric consumer during the applicable billing period.
>
> "Net metering policies can vary significantly by country and by state or province: if net metering is available, if and how long you can keep your banked credits, and how much the credits are worth (retail/wholesale). Most net metering laws involve monthly rollover of kWh credits, a small monthly connection fee, require monthly payment of deficits (i.e. normal electric bill), and annual settlement of any residual credit. Unlike a feed-in tariff (FIT) or time of use metering (TOU), net metering can be implemented solely as an accounting procedure, and requires no special metering, or even any prior arrangement or notification.
>
> "Net metering is a policy designed to foster private investment in renewable energy. In the United States, as part of the Energy Policy Act of 2005, all public electric utilities are required to make available upon request net metering to their customers."

80 http://www.doe.gov.ph/netmeteringguide/index.php/1-how-net-metering-works-understanding-the-basics-of-policy-regulation-and-standards.

Wikipedia very clearly defines net metering in terms of offsetting "electric energy" and "kWh credits", not terms of currency or monetary amounts. The offsets or credits are in kWh, because that is what the electric meter records, and when the flow of energy goes in either direction, the meter records only the net flow. Hence, *net metering*. By its very definition, net metering is based on parity pricing, incoming and outgoing kWh have the same price, that is why only the net flow is billed.

In fact, while Wikipedia is a good starting point for gathering research leads, it is a poor source of authoritative information. No respectable scholar would cite it as an authoritative source because anyone can change Wikipedia entries anytime, and resolving Wikipedia disputes about such changes can take months or even more, if they are ever resolved at all.

Let us cite instead a net metering expert who studied this approach for the US Department of Energy's NREL. Here is what Yih-huei Wan says: [81]

> "The concept of net metering programs is to allow the electric meters of customers with generating facilities to turn backwards when their generators are producing more energy than the customers' demand. Net metering allows customers to use their generation to offset their consumption over the entire billing period, not just instantaneously. This offset would enable customers with generating facilities to receive retail prices for more of the electricity they generate. Without a net metering program, utilities usually install a second meter to measure any electricity that flows back to the utility grid and purchase it at a rate that is much lower than the retail prices."

The DOE "net-metering" guide specifies a second meter and a blended generation charge, which is lower than the retail price. Thus, the DOE guide specifies what is precisely *not* a net metering program.

Yih-huei Wan further describes the advantage of net metering:

> "The strength of net metering lies in its simplicity: the use of a single meter. It does not need constant regulatory interaction or supervision after the program is in place. No requirements are made of utilities. It allows customers to make renewable energy technology choices and only impacts the customer's meter. As a policy option, net metering provides economic incentives to encourage renewable energy technologies without public funding. Because more of the customer-generated electricity can receive a utility's retail price, it can lower the economic threshold of small renewable energy facilities."

In short, net metering is a good way to open participation by small players in the government's RE program, with minimum of regulation, supervision and public funding.

Lowering the economic threshold: batteries not needed

Solar panels have no output at night. The standard solution is to store their daytime output in batteries, for use at night.

One way that net metering can lower the economic threshold for small players is that it obviates the need for batteries, which are expensive, short-lived, difficult to maintain and also a common source of failure of solar PV systems.

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81 Yih-huei Wan, *Topical Issues Brief: Net Metering Programs,* 1996. p. v.

Net metering customers do not need batteries for night time use because they can accumulate credits with the utility during the daytime by exporting their surplus. They can then draw these credits from the utility at night.

Thus, net metering customers do not need batteries at all (unless they want electricity when the grid is down). Their PV set up becomes cheaper, simpler to set up, and easier to maintain, lowering further the barriers to entry into the government's RE program.

The "net-metering" scheme currently implemented by utilities such as Meralco is contrary to law. The 2008 Renewable Energy Act provides for charging only the net electricity consumption by consumers who feed their renewable energy surplus back to the utility. Meralcco charges more than this.

Some DUs can do worse than this, if they replace existing meters with uni-directional electric meters.[82] This kind of meter will move forward, whether the customer is getting electricity from the grid, or exporting his surplus from the grid. This means that solar rooftop owners exporting their surplus to the grid not only do not get paid, but they will even be charged for it, both the surplus returned as well as the delivery charge. Instead of getting paid the full amount, they will be charged the full amount! This effect was actually documented in a study of a water-refilling station with a 3-kWp PV system connected to the grid via a uni-directional meter.[83]And since the neighbors' use of the exported surplus will also register in their electric meters, the neighbors will also be charged for the same surplus, a bizarre case of triple-charging. (See Chapter 8 for details.)

The government should not allow these multiple-charging schemes to persist, especially through uni-directional meters, which enable utilities to scam their customers, as explained in another chapter.

In 2015, there were less than 300 registered net-metering customers in the Meralco service area.[84] The paltry number attests to the solid barriers that exist in the Philippines today against net metering and solar rooftops. By August 2016, there were still less than 450 net-metered users nationwide. The success of Philippine electric utilities in undermining the net metering provisions of the RE Act might unfortunately have given all utilities the lessons they are now applying in the U.S.

A common reference price (parity pricing) corrects the double-charging

To correct the double-charging scheme, the government should order the distribution utilities to give those who export their surplus electricity full credit for their exported surplus. Full credit means the same reference price for kWh in and kWh out.

Once the authorities acknowledge that a common reference price will rectify the double-charging scheme, they will also realize that parity pricing is very simple to implement—just

82 The author confirmed from a technician working with one distribution utility that they install uni-directional meters.

83 Erees Queen B. Macabebe, et al., "Performance of a 3-kWp grid-tied photovoltaic system in a water refilling station" (Paper presented at the 5th International Conference on Sustainable Energy and Environment: Science, Technology and Innovation for ASEAN Green Growth, 19-21 November 2014, Bangkok, Thailand).

84 This information came from ERC Executive Director Francis C. Juan in his keynote talk at the "National Legal Conference on Renewable Energy" sponsored by the Friedrich Ebert Stiftung – Philippine Office and the Center for Renewable Electricity Strategies, and held in Manila on Oct. 22-23, 2015.

retain the analog meters that turn back when a client exports electricity to the grid and make sure that any electric meter replacement, including digital ones, will likewise reverse their reading properly when the flow of energy through the meter also reverses. This is true net metering—one that prevents utilities from double-charging its RE clients.

We badly need in the country today **true net metering**, where, with no modification to existing utility service, connections or electric meters, consumers can simply plug in a solar-driven inverter that meets government and international standards and their outgoing surplus will turn their electric meter backwards.

Net metering requires no technical or administrative action from the distribution utility. Neither the government nor the utilities have to do anything, for consumers to enjoy net metering. Most analog meters, will automatically run backward if electricity flowed out instead of in. All the consumers need is the right inverter, an MPPT inverter that meets the standards of the electricity industry. Net metering took off in many countries because of its simplicity, in concept and in operation.

As long as utilities stick to electric meters that reverse when the consumer exports his surplus and consumers use only certified grid-tie inverters, net metering will happen as a matter of course. Even the old accounting and billing methods will work as usual. Joining the government's RE program using solar panels and an inverter will then become as easy and as simple as plugging in any other appliance, like a refrigerator—plug and forget.

It is of course important for the consumer to inform the DU, as they do in Germany, to spare the DU of conducting unnecessary investigations should they mistakenly accuse their legitimate net metering customers of tampering with electric meters to reduce electricity bills.

By the way, this is how net metering is implemented in Germany: "German homeowners simply informed their utility that they would be connecting a PV system. The utility was obliged, by law, to accept the connection."[85]

Exporting one's RE surplus to the grid is definitely legal. There is nothing illegal in returning a product like LPG tanks or electricity and asking your willing neighbor to pay for it instead. In fact, our RE law makes this explicit by requiring DUs to accept the exported surplus, and to charge the RE exporter only his net electricity consumption.

It is the simple, time-tested, approach of net metering which will enable the ordinary low-income consumer to enjoy the benefits of clean energy and cheaper electricity without any red-tape, without any hassle. With the price-barrier gradually receding, and as variousfinancing schemes become available to small players, true net metering will open the floodgates for "solar selfies," the soon-to-be-common phenomenon of self-generation of electricity by solar-enabled households and small enterprises.

85 Johnstone, p. 251.

Net metering is pro-poor

True net metering will enable even the lower-income utility customers to save the ₱3.00 per kWh that former Secretary Petilla had referred to, when they shift from utility electricity to rooftop solar electricity.

Imagine an ordinary worker who can only afford a 100-Wp grid-tied solar home system costing around ₱11,000.00, perhaps paid through a special SSS, GSIS or Pag-IBIG loan or an RE window of the Land Bank. Since most wage-earners are at work during the day, they will not be able to use the electricity generated by their PV system. Adding a battery is out of the question, because it would make the system more expensive and less viable, not to mention more complicated to maintain.

With net metering, wage-earners can export all or most of their daytime output to the grid and accumulate kWh credits, recorded as a reverse movement on their electric meter readings. Then, when they go home in the evening, they can use these credits, their meter reading turning in the forward direction as usual. They will save from their electric bills more than enough to pay for the monthly amortizations for the PV system. And when it is fully paid, they will be saving even more, month after month, year after year, through the lifetime of the PV system.

The larger the PV capacity they can afford, the bigger their savings.

The only risks they have to guard against are catastrophic events like typhoon damage or equipment theft. If some government agency sold insurance for these kinds of risks, then workers can be protected against them too.

In short, net metering—and FIT too, if the Philippines followed the German model of encouraging the entry of small players into the FIT system—will immediately benefit even poor electricity consumers, especially if they received help in acquiring PV systems through low-interest loans.

Net metering is what we need today

In the context of the decade of the 2000s, in the specific conditions of Germany, FIT was the right mechanism to jumpstart the renewable energy industry.

But this is now the decade of 2010s. Solar panels today cost, on the average, 50% less than they did a decade ago. Electricity from solar rooftops is cheaper today than electricity from the grid. Because our electricity rates are one of the highest in the world, reducing one's electricity bill is a very important motivator among consumers. Thus, in this country, the mechanism that we most badly need at this time is true net metering, where, with no modification to existing utility service, connections or electric meters, consumers can simply plug in a solar-driven inverter that meets international industry standards and their surplus electricity makes the meter turn backwards.

Limitations of net metering

In countries at the forefront of RE advocacy, net metering and parity pricing do not go far enough, because they assign the same price to fossil-based grid electricity and to clean, renewable electricity. In these countries, typified by Germany, RE advocates have won so much ground that they can now demand and governments have agreed, that renewables should be paid *premium* prices. Renewables deserve a higher price, their argument goes, because they supply the grid with clean, renewable energy and have much lower externalized health, social and environmental costs than fossil- and nuclear-derived energy.

The justification for a premium price is especially strong for solar projects, whose outputs are highest during hours of peak demand. A solar PV system that peaks at noon will be supplying electricity to the grid at peak hours, when the utility would otherwise need to buy from expensive peaking plants that also sell at premium prices. Net metering fails to take this into account.

The desire to go beyond the limitations of net metering and other approaches eventually led advocates to what turned out to be the most successful policy instrument yet for promoting renewable energy—feed-in-tariffs (FIT).

This will be explained in the next chapter.

Chapter 13
Feed-in-Tarriffs: Germany and Spain

The most successful mechanism in encouraging RE development so far is an approach called the feed-in-tariff (FIT), where tariff means payments to the providers of electricity and feed-in-tariffs are the payments to owners of renewable systems that "feed in" to the grid.

The core idea that made FIT so successful is the idea that the income from RE investments must be high and stable enough over at least the payback period of the project, so that lending to FIT-supported RE projects becomes a low-risk affair. If this is so, then the financing will come.

And this is exactly what happened in Germany.

Best example of FIT: Germany

The policy innovation that has succeeded best in encouraging RE development is FIT, in particular, the version that has been implemented by the German Federal government. The German FIT system contained the following features: [86]

1) Higher tariffs (fixed rates over a 20-year period) were mandated for cleaner, renewable energy sources to encourage their further development.

2) The utilities and the grid were obligated by law to accept and dispatch on priority basis electricity generated from clean renewable sources.

3) As the share of clean renewables in the energy mix increased, the higher tariffs were reduced accordingly for later participants (the industry term is "degressed"), to reduce the impact of the FIT system on electricity prices.

86 Johnstone, p. 191.

4) The higher tariffs are paid from a universal charge that is collected from all electricity consumers, and not from government subsidies.

5) These measures were meant to ensure the financial viability of RE installations, making them attractive borrowers for commercial lending institutions.

6) The paperwork required to join the system was drastically reduced.

7) Small players were particularly encouraged to join the program.

With this system (the law was adopted in 2000, and amended in 2004), the German renewable energy sector took off.

Germany is now one of the world leaders in terms of the rapid increase in the share of renewables in the energy mix (23.4% in 2013, from 6.2% in 2000). Germany plans to close all its nuclear power plants in 2022. By this time, they plan to source 40–45% of their electricity supply from renewables. By 2035, the figure will be 55–65%, and by 2050, 80%.

Germany did not leave the ordinary households behind. By 2014, some 1.2 million households have installed solar PV systems, not only because they wanted a clean, renewable source, or because they preferred greater independence from the grid, but also because they got extra income by doing so. By 2015, the number had reached 1.5 million.

They obtained loans from banks, set up the PV system, join the FIT program, paid their loan amortizations regularly, and had money to spare.

These 1.5 million households have also become a major political force that no political party could afford to ignore. More Germans are employed in the solar and wind sector today than in the coal sector. When suggestions to phase down the FIT system are raised, threatening to slow down the energy transition to full renewability, they mobilize and intensify their lobbying, providing a counter-balance to the powerful nuclear and fossil-fuel lobbies.

By 2014, some 1.2 million German households have installed solar PV systems. **By 2015, 1.5 million.**

Germany's spectacular success has become a model for the rest of the world.

Spain: FIT systems can fail too

An illustrative case study of FIT failure is Spain, where a modified FIT was launched in 2007 and ended disastrously. The Spanish case has since served as a negative example of how not to do FIT.

Although it modeled its FIT after Germany's, Spain made a few modifications of its own. The changes turned out to be ill-conceived.

The Spanish government decided to pay for the premiums itself, rather than pass on the cost of the program to consumers. The high FIT rates were also locked in, and the degression provisions omitted.

The high, locked-in FIT rates, plus incident solar radiation that was twice Germany's, offered investors extremely high rates of return. The attractive margins drew a rush of opportunistic investments. A speculator-driven boom ensued, involving mega-scale installations.

In the meantime, households found it hard to participate because of the bureaucratic requirements built into the system.

As the flood of speculative investments fueled itself, the boom turned into a bubble. The government found itself unable to pay the potential $26 billion bill.

The bubble eventually burst and many projects collapsed, as the government backed out of its initial commitments.

It is not as bad as the anti-renewables put it, though. Today, Spain is trying to pick up the pieces, and its renewable energy sector may yet rise from the ashes. The speculators were properly punished by the market, but many solid projects survived. Spain just needs to learn from its hard-earned lessons, so that it can resume its march towards its own energy transition.

Around the time Spain's FIT was heading towards a bubble, other countries were also looking at adopting the FIT system. One of these countries was the Philippines.

In the next section, we will see how the FIT concept was implemented in the Philippines.

Chapter 14
It's more FIT in the Philippines

Following the success of feed-in-tariffs (FIT) in Germany, many countries followed suit, hoping to replicate the German success in encouraging the rapid growth of their renewable energy industry.

The Philippines is one of the countries that also incorporated a FIT system in its renewable energy law. Understandably, the Philippines made modifications on the German model, to suit the system to its own requirements and particularities.

The Philippine FIT system

Like Germany, the Philippine FIT also guarantees a market and at fixed rates (called the FIT rates). Four types of renewables are covered in the Philippine FIT—solar, wind, run-of-the-river hydro, and biomass—each getting its own FIT rate. The rates are fixed and guaranteed for at least twelve years. Developers who are eligible for FIT enjoy priority connections to the grid and priority in purchase, transmission and payment by the grid system operators.

The Department of Energy (DOE) emphasizes that the FIT system is only one among an RE developer's market options. A developer's market options include: sell the output to a local electric cooperative or distribution utility; sell to a large consumer; sell to the wholesale electricity spot market (WESM); and non-fiscal incentives like the FIT.

FIT rules have been promulgated by Energy Regulatory Commission (ERC). A DOE order was also issued, Department Circular 2013-05-0009 entitled "Guidelines for the Selection Process of Renewable Energy Projects Under Feed-In-Tariff System and the Award of Certificate for Feed-In-Tariff Eligibility."[87] The circular specified the criteria and rules for selecting FIT-eligible proponents.

87 "Department Circular No. DC-2009-005-009," Department of Energy, May 28, 2013, http://www.doe.gov.ph/doe_files/pdf/Issuances/DC/DC2013-05-0009.pdf.

There are two rates under the FIT system: the FIT rate, which is the rate paid to RE producers, and the FIT allowance ("FIT-All" in industry lingo), which is the universal charge collected from all consumers. The FIT allowance will go towards paying the FIT rates. The fund administrator for the collected fund is the National Transmission Corporation, which pays the RE producers based on the FIT rate. As approved by ERC, the FIT rates (in pesos per kWh, valid for 20 years) and thresholds are:

Table 35. FIT Rates and Thresholds

RE Technology	1st (2nd) FIT rate (P/kWh)	Degression rate	Installation threshold (MW)
Solar	9.68 (8.69)	6% after 1 year from effectivity of FIT	70 (430)
Wind	8.53 (7.40)	0.5% after 2 years from effectivity of FIT	200 (200)
Biomass	6.63	0.5% after 2 years from effectivity of FIT	250
Run-of-river hydropower	5.90	0.5% after 2 years from effectivity of FIT	250
Geothermal		Excluded	

Source: DOE, 2013; Rivera, Danessa, "ERC limits new wind FIT rate to 3 projects", *Philippine Star*, Dec. 4, 2015, http://www.philstar.com/business/2015/12/04/1528657/erc-limits-new-wind-fit-rate-3-projects

The above rates are fixed, regardless of changes in the grid rates.

When the thresholds are exceeded for each category, the FIT rates for the next batch of developer-applicants will be "degressed" (i.e., reduced according to a fixed schedule). The lower rates will apply to the subsequent batch of FIT applicants. Those who made the threshold will enjoy the higher, non-degressed rates for 20 years.[88] The degression rates are also specified in the third column of the preceding table. "Effectivity of FIT" refers to the date the FIT allowance is approved.

The Philippine FIT system is a race to finish one's project ahead of the others. The developers who get their Certificates of Completion before the threshold is completely filled up get to enjoy the FIT rate before it is degressed. Those that get their Certificates after the threshold is filled up will have to live with the degressed FIT rates. After the first degression, the ERC, upon the recommendation of the NREB, decides on the new thresholds and FIT rates.

According to DOE's Renewable Energy Management Bureau (REMB) Director Mario Marasigan, the high degression rate for solar is based on the rapid decrease in the cost of solar panels.

RE Service Contract first, then Certificate of Registration

Before one can avail of FIT and other incentives, 2008 RE Act requires RE developers to first register with DOE through REMB.[89] However, before RE developers get a DOE Certificate of Registration, they must hold a valid RE Service/Operating Contract.[90]

88 The 2008 Renewable Energy Act says "at least 12 years;" ERC set it at 20 years.

89 Republic Act 9513, Section 25.

90 Ibid.

To implement the two provisions above, the DOE spelled out in its Circular No. 2013-05-0009 the guidelines for the selection of projects that would qualify under the FIT. The guidelines provide that "only those RE Developers with valid and subsisting Renewable Energy Service Contracts may apply for the eligibility and inclusion of their project under the FIT system."

RESC, first step

To get a service contract though, one has to undergo an application process first. The applicant must meet several requirements: 1) payment of the application and processing fees;[91] 2) Filipino ownership (60% Filipino for corporations, except for geothermal projects, which can be foreign-owned); 3) SEC registration;[92] as well as 4) legal, technical and financial requirements.

Legal requirements

For single proprietorships, the legal requirements include: 1) National Statistics Office (NSO)-certified true copy of birth certificate; 2) business permit; and 3) other applicable documents.

For corporations, the requirements include: 1) original copy of certification from its Board of Directors or officers authorizing its representative to negotiate and enter into an RE Contract with the DOE; 2) duly certified Articles of Incorporation or equivalent legal documents; 3) latest General Information Sheet or equivalent, with the names of its officials, ownership, control and affiliates.

Foreign corporations engaged in geothermal projects must get their documents duly authenticated by the Philippine Consulate having consular jurisdiction over them.[93]

Technical requirements

The applicant must also possess the necessary technical capability to undertake the obligations under the RE Service Contract in terms of track record or experience, work program, key personnel experience, and existing company-owned equipment for RE operations and any leased RE equipment.[94]

Financial requirements

The proponents must submit the following financial documents: 1) audited financial statements for the last two years and unaudited financial statement if the filing date is three months beyond the date of the submitted audited Financial Statement; 2) Bank certification to substantiate the cash balance in the audited Financial Statement or updated Financial Statement; 3) Projected cash flow statement for two years; and 4) List of company-owned equipment/facilities available for the proposed RE projects.

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91 Ibid, Section 6 (a.iii).

92 Section 6(a) of Department Circular No. DC 2009-07-0011, "Guidelines Governing a Transparent and Competitive System of Awarding Renewable Energy Service/Operating Contracts and Providing for the Registration Process of Renewable Energy Developers."

93 Ibid, Section 6(b).

94 Ibid, Section 6(c).

If the RE applicant is a relatively new company, and cannot produce the documents above, it can submit instead 1) an audited Financial Statement and duly certified and/or notarized guarantee or Letter of Undertaking/Support from its parent company or partners to fund the proposed Work Program;[95] and 2.) Proof of the ability of the RE Applicant to provide the required minimum amount of Working Capital which shall be equivalent to 100% of the cost of its work commitment for the first year of the proposed Work Program. In the case of foreign parent-company, the audited Financial Statement and the guarantee or Letter of Undertaking/Support shall be duly authenticated by the Philippine Consulate Office that has consular jurisdiction over the said parent company.

RESC, second step

The second step in securing the RE Service Contract is by participating in the award process of the DOE. There are two ways: 1) through an open and competitive selection process or 2) through direct negotiation.

Open and competitive selection process involves 1) invitation for submission of RE project proposals; 2) submission of project proposal; 3) creation of a review committee to evaluate the proposal; 4) evaluation by the review committee based on the rules that it will set (Note that the evaluation of the technical and financial criteria shall proceed only after a finding that all the legal requirements have been complied with); and 5) notification as to the result of the evaluation.[96]

The other mode of awarding RE contracts is through direct negotiation, within a minimum period of 120 days, of the terms and conditions of the contract between the DOE and the RE applicant.[97] Direct negotiation is allowed only under the following circumstances: 1) in "frontier" areas, where the DOE can find no sufficient technical data available; and 2) if the open and competitive selection process fails because a) no RE proposal was received by the REMB; b) the Review Committee determined that no applicant met the legal requirements; or c) some applicants met the legal requirements, but the Review Committee determined that no applicant complied with the technical and financial requirements.[98]

RESC, third step

If the applicant qualifies, then the Review Committee recommends approval of the RE Service Contract by the DOE Secretary, who then signs it. If the application involves an FTAA, it is the President of the Philippines who must sign the contract. The qualified applicant is then duly notified.[99]

Posting a bond

Within 60 days after the RE Service Contract takes effect, and at the start of every contract year thereafter, the RE developer is required to post a bond or any other guarantee of sufficient amount. The bond should not be less than the minimum expenditures commitment for the corresponding year.[100]

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95 Ibid, Section 6(d).
96 Ibid, Section 9.
97 Ibid, Section 10 (a).
98 Ibid, Section 10.
99 Ibid, Section 11.
100 Ibid, Section 13.

Finally, the Certificate of Registration

Once the RE Service Contract takes effect, the RE developer shall be registered in the DOE and issued a Certificate of Registration.[101]

Can I FIT now?

Given an RE Service Contract and a Certificate of Registration, can RE developers now join the FIT? Apparently, not yet. They can only do the feasibility studies and other activities associated with the pre-development stage of the project, to determine if the project is in fact commercially viable. For the actual project development stage, the RE developers again have to undergo another process of application, and have to comply *once more* with documentary and technical requirements, as provided in DOE Circular No. 2013-05-0009.

Application to convert, first step

The developer has to apply again, to convert its RESC, which is still at the pre-development stage, to the development stage. It needs to submit a Declaration of Commerciality, informing the DOE that the project is in fact commercially viable on the approved FIT rate.

Application to convert, second step

The DOE evaluates the application.

Application to convert, third step

The DOE issues a Certificate of Confirmation of Commerciality, which is in effect the notice to proceed to the construction phase under the Development Stage. The DOE may likewise issue an endorsement to the National Grid Corporation of the Philippines (NGCP) for the conduct of requirements for interconnection such as Grid Impact Study and Interconnection Agreement, if applicable.

Application to convert, fourth step

Finally, the DOE issues a Certificate of Endorsement for FIT Eligibility (CEFE).

Can I FIT now?

Not yet, because the CEFE involves, in turn, several more technical processes . . . (After all, it is just an "endorsement" that the applicant is "eligible.")

Towards the end, the FIT "eligibility" turns out to be eligibility to join a race to build the RE facility. The earliest finishers—the winners—are entitled them to enjoy the FIT rates announced earlier. Once the threshold for a particular technology (solar, 50 MW; wind, 200 MW; hydro, 250 MW; and biomass, 250 MW) is exceeded, the late finishers slide down to the lower "degressed" rates, presumably to continue the race. However, the rules are not clear what the next thresholds are, and what new certificates are required, if any.

101 Ibid, Section 15.

Clearly, the process described above reflects our 300 years of Spanish tutelage, more than any appreciation of German efficiency.

Our feed-in-tariff system reflects our 300 years of Spanish tutelage, more than any appreciation of German efficiency.

Despite the convoluted process of joining the FIT race, the potential gains were large and attractive enough that hundreds of RE developers applied just the same.

There are currently more than 500 RE service contracts, mostly in the pre-development stage. The thresholds for wind and solar have already been exceeded, and there have been demands from industry to raise the thresholds.

Director Marasigan says all of the service contracts are listed on the DOE website (see www.doe.gov.ph/awarded-projects/awarded-wind, www.doe.gov.ph/awarded-projects/awarded-solar, www.doe.gov.ph/awarded-projects/awarded-hydropower, and so on). There is also another monitoring board online for the FIT system (see www.doe.gov.ph/feed-in-tarriff-monitoring-board/for-conversion-from-pre-development-to-development-commercial-stage and www.doe.gov.ph/feed-in-tarriff-monitoring-board/with-certificate-of-confirmation-of- commerciality).

Under the current policies of DOE on FITs, it is quite clear that the cumbersome process to join is a huge barrier to small players, making it available only to big players. While there is no express prohibition against households and building establishments joining the FIT system, the number, nature and cost of the requirements are so daunting that only the big players with deep pockets would be able to comply.

Can small players FIT?

There *are* provisions in the guidelines in securing RESC for micro-scale projects: sections 26, 27 and 28 of DOE Circular No. DC 2009-07-0011.

Section 28, in particular, provides for a set of “simplified” procedures and requirements for the grant of RESCs for own-use and micro-scale RE projects. But the rules have not been released yet.

As far as the bureaucratic requirements of its FIT system are concerned, the Philippine FIT is closer to the Spanish rather than the German model. The system is obviously designed for big players, including foreign companies who may not have the local track record yet, but can bring in capital and technology. The FIT system simply has no place for ordinary workers or employees who may want to install solar panels on their rooftops and enjoy the incentives and benefits offered to the big players.

This would have been alright, if small players could enjoy the simplicity and savings of true net metering, giving them even better rates of return than Philippine-style FIT.

However, it turns out that when the big players were negotiating the FIT with the government, and complained about the approval of the FIT allowance taking too long, the government side decided to appease the big players by quickly redesigning net metering and offering it to the latter as an interim measure. DUs apparently took advantage of this rare opportunity to redefine net metering to their advantage. Thus, the small players lost what would have been the simplest way for them to participate in the government's RE program. (See Chapter 12 for details.)

Conclusion

The essence of the FIT is to assure RE investors a stable, low-risk, and high-enough return on investment to encourage more investments in the RE sector. In the successful German FIT approach, households and other small players were also seen as investors, and their participation in the system was highly encouraged.

The Philippine system has several features of the successful German FIT system, but it does not have the friendliness of the latter to small players. Instead, the bureaucratic FIT requirements are closer to the unsuccessful Spanish model, which also kept the small players out of the FIT system.
Whether the Philippine government can recognize this flaw, among several others, and move quickly enough to correct it, will probably determine how much of a success the Philippine FIT will turn out to be.

The worst feature of the Philippine FIT system is its flawed design as a race to finish. Those who join the race will only know after the race is over—after billions have been spent to construct and commission the plants—who will actually get the FIT benefits.

Companies know their own capabilities—their costs, and the time it will take them to finish their project. But they can be hardly expected to know as accurately those of their competitors. If they guess wrongly, or their competitors exert extraordinary measures to finish ahead, the race losers will only know after the projects are done. Gambling on such an uncertain result will raise, not bring down, project risks and borrowing costs.

Risk reduction was the key to the success of the German FIT system. The Philippine FIT design increased the investors' and lenders' risks, instead of reducing them.

In fact, this author has come to the conclusion that we do not need FIT anymore. The FIT universal charge has been raised from the initial four centavos per kWh to twelve centavos, with a pending proposal to raise it further to 23 centavos. This system is now running the risk of becoming another milking cow for rent-seekers who may try to get special privileges in accessing the accumulated FIT funds. This is a common problem when funds that are accumulated for a specific purpose run into billions, attracting corrupt operators like ants to sugar.

Generation costs are "pass-through" costs, and are merely passed on by the electric utilities to the consumer. The average generation cost is in fact listed separately in the consumer's electric bill. Thus, even before the FIT system was implemented, a system for collecting these pass-through costs already existed, taking care of passing on premium payments to consumers. For instance, fossil-fueled peaking plants charge a premium to come online during peak hours. Yet, no separate universal charge is collected for them. The peaking plants charges simply become part of the average generation cost that is passed on to the consumer, raising the price of electricity. Why not use the same transparent system for FIT developers? The only difference is that the amounts due them will be based not on market-determined nor contracted rates but on the FIT rates.

In short, a system for collecting payments for various power plants already exists, and renewables can simply fit into this system, without the need to collect a universal charge that will be accumulated by a fund manager and which will attract the attention of operators who specialize in tapping into such funds for all kinds of nefarious objectives. We fear that the FIT universal charge will attract the corrupt like sugar attracts ants, and the fund will go the way of other funds collected by the government. Instead of becoming smaller, as the cost of renewables goes down, operators will now want the charge to get larger and larger, turning it into a potential milking cow for insiders who have mastered the art of gaming these funds. Already, the FIT universal charge has been raised by 300% of the original, with a pending proposal for another 100% increase on top of this.

The FIT system has achieved its purpose, which is to open the minds of investors and lenders to the viability of renewable projects. It is time to end it, before it morphs into something else.

The next chapter will discuss other policy options for encouraging renewables.

Chapter 15
Other RE policy options in the Philippines

The Renewable Energy Act of 2008 specifies five other approaches for encouraging RE development, aside from net metering and FIT, which have been covered in previous chapters. The other five approaches are:

1. Renewable portfolio standards (RPS)

RPS are what this study called mandated targets in Chapter 7. Electricity suppliers or DUs are required under RPS to produce from RE sources a specified minimum percentage of their electricity, as set by the NREB. RPS involves RE certificates earned by certified RE generators whenever they produce a specified amount of electricity. RE generators can then sell these certificates to distribution utilities, separately from the electricity itself. To prove compliance with RPS standards, DUs must submit to a regulatory body RE certificates, which can be bought from certified RE generators.

A lot of details still have to be worked out, for the RPS to work properly. These details are supposed to be incorporated into implementing rules and regulations (IRR). The details include the types of RE resources, the process of identification and certification of RE generators, the annual process of setting the minimum RE requirements (not less than 1% of demand over the next 10 years), the rules for trading certificates in an RE market, and so on.

One can only hope that the Spanish style of bureaucracy will not manifest itself once more in the RPS, as it did in the FIT. Hoping for the best, it would be nice to see a place for households and other small players on the RPS table, so that their solar rooftops can be entitled to RE certificates too, and that they too will be allowed to sell these certificates to the highest bidders.

So far (as of August 2016), the RPS Implementing Rules and Regulations (IRR) have not been issued yet, so there might still be an opportunity to make sure the flaws in the government's FIT and net metering approaches are not repeated under the RPS.

2. Green Energy option (GEO)

This approach gives consumers a choice: electricity end-users may choose an RE source as their source of electricity to ensure that their payments go to operators of RE facilities rather than to fossil-fueled plants. If enough environmentally conscious end-users are willing to pay a premium price for renewable electricity—just as health-conscious families are willing to pay premium for organic foods—this might even preclude the need for a universal charge for RE.

As in the RPS option, lots of details have to be worked out, and the devil lies in ambush.

But the details have been worked out in other countries like the US and Germany, which made this option available much sooner.

Originally, the option was part of the regulatory process within the electricity industry, which enabled DUs to choose which electricity suppliers they could buy electricity from, although they all used the same grid. GEO extends the freedom of choice to consumers themselves.

If the GEO IRR is promulgated with the small players in mind, one can imagine setting up solar panels and marketing one's surplus to relatives and friends, until the latter decide to install solar panels themselves. Used imaginatively, GEO will make a great marketing vehicle for RE.

3. A minimum percentage of RE for off-grid areas

This provision of the 2008 Renewable Energy Act seems specifically addressed to the Small Power Utilities Group (SPUG) of the National Power Corporation. It requires those who provide "missionary" electrification to source a minimum percentage of their annual output from available RE resources in the area. The minimum percentage would be recommended by the NREB.

The operators of the local RE resources would be entitled to RE certificates. If the local electricity providers are unable to identify and use local RE resources, they can instead buy RE certificates elsewhere, as provided under RPS.

4. Micro-scale projects

Since the government claims to own solar and wind resources, it insists that as owner, it is entitled to a share in an RE developer's profit. And the government in fact gets a share in the profits of the big players.

However, it has decided to be generous to small players. For what it calls "micro-scale" projects, which it defines as projects not greater than 100 KW in capacity, Section 13 of the Renewable Energy Act waives the government's share of the proceeds of micro-scale projects for communal purposes and non-commercial operations.

Perhaps such government generosity will encourage more communal and non-commercial efforts to tap renewable sources.

5. Other government incentives

Other incentives include the usual income tax holiday, duty-free importation, special tax rates, net operating loss carry-over, lower taxes rates on corporate net income, accelerated depreciation, zero percent VAT, cash incentives for RE developers for missionary electrification, tax exemption of carbon credits, tax credits on domestic capital equipment and services, and other goodies.

Of course, to avail of these goodies, one has to be registered with the DOE. And before one can register with the DOE, one has to have an RE Service Contract. And before one can get an RE Service Contract, one has to . . . (Read about the bureaucratic maze once more in Chapter 14.)

Chapter 16
The special role of solar rooftops

They are called “solar home systems” (SHS) in some countries. Terms like “distributed solar”, “residential solar”, and “rooftop solar” have also been used. In today's lingo, they will probably be called “solar selfies.” In the context of the benefits of micropower in general, another appropriate term is “microsolar”.

It is important for policy makers and the public to understand why household-scale and other small-scale solar power generation should get as much support, if not more, as utility-scale solar PV plants and other renewables.

The building block of photovoltaic (PV) systems, whether at the sub-kilowatt household level or at the multi-megawatt utility level, is the PV cell. A typical cell is about as large as a smartphone and produces at most around two watts under a full sun.

All PV systems big and small use this same building block. First, the cells are connected in series (the positive end of one to the negative end of the next) to build up the output to a particular voltage standard. This is similar to the way four 1.5-volt (V) batteries are connected in series to reach the 6 V needed to run a transistor radio. For solar panels, the typical standard voltage for this next-level building block is around 18 V, suitable for charging 12-V batteries. Other panels have higher voltage outputs, for charging 24-V batteries. In the future, panels that can charge 48-V batteries for electric vehicles) may become common, but they will, in all probability, use the same building block.

There is no fundamental difference between household-scale and utility-scale solar plants. They use the same building block.

The blocks are further connected in parallel (all positive ends form one connection, all negative ends form another connection) to increase their peak wattage, resulting in the standard commercially-available PV panels. In the

Philippine market today, one can find 5- or 10-Wp PV panels (usually for cellphone charging), up to 100- or 150-Wp panels for roof-mounted household PV systems. Recently, 250-Wp panels have become more common and 300-Wp panels are just coming into the market.

These commercially available panels are simply combined in larger solar arrays (in series to increase the voltage, and in parallel to increase the current) to reach whatever levels are required by the household or the utility. The San Carlos Solar Energy (SACASOL) utility-scale PV plant, for instance, used 88,000 150-Wp panels to get its peak output of 22 MW.[102]

Thus, there is no fundamental difference between the household-scale and the utility-scale solar plant. The latter simply uses more of the same building blocks.

A second important point to consider is that PV systems (and other electrical generation facilities) are most efficiently operated at the point of use. The farther away the source is from the point of use, the more losses due to wire resistance will be incurred in supplying electricity from the source to the user. By minimizing system losses associated with transmission and distribution, practically the full PV output becomes available to the end-user. This results in very high efficiencies, instead of electricity being dissipated as waste heat in the transmission and distribution system.

There are additional reasons why electrical generation is most efficiently operated at the point of use:

1. *Less investment in transmission and distribution.* The need for investment in transmission and distribution lines, and their associated control facilities is minimized. The need for these lines cannot be entirely eliminated, because PV users need to take electricity from the grid when there is not enough sunshine. They can also sell electricity to the grid in times of excess production. The grid is also needed for the transmission and distribution of wind, hydro and other utility-scale renewables.

2. *Less investment in spinning reserves.* The need is also minimized for investments in huge spinning reserves, which are plants generating electricity on standby, ready to take-over in case the largest plant on the electric grid fails.

3. *Less land needed.* Because household-scale systems can be roof-mounted, the need is also minimized for huge tracts of land exclusively for solar power generation.

4. *PV panels as roofs will reduce roofing costs.* In the future, even greater savings can be incurred when PV panels themselves are used as roofing material, reducing the need for galvanized iron and other roofing materials.

Consumption at source minimizes system losses as well as investments in transmission and distribution

5. *Expansion in smaller steps in less risky.* The incremental investments for new solar installations can occur at the kilowatt and sub-kilowatt levels instead of megawatt and gigawatt levels. Thus, expansion can occur in small steps, made by many, instead of the riskier big leaps, made by a few.

102 "Solar Energy," Bronzeoak Philippines, (Accessed January 29, 2015), http://www.bronzeoakph.com/solar.html.

6. *Technology lock-in is avoided.* The smaller incremental investments reduce the risk of technology lock-in. Technology lock-in is a major problem in long-gestation, multi-million dollar projects such as coal and nuclear plants, which can commit a society to a specific technology for decades to come. Thus, if a superior technology for electricity generation were to become viable next year, a country with a coal or nuclear plant project that is, for instance, nearly complete would be faced with a huge dilemma what to do with a white elephant. The small incremental investments needed for household-scale solar power avoids this kind of long-term technology lock-in.

7. *In general, distributed approach is usually better*. A further advantage of including small-scale production reflects the advantages in general of a distributed over a centralized approach. The advantages of a distributed approach can be seen in the rapid growth and huge success of the information Internet.

Given these additional efficiencies and other advantages realized by household-scale solar power generation, it is essential therefore to prioritize households and similar small-scale entities into the various government incentive systems for solar power and other clean renewables, including the FIT system. Ordinary citizens should be able to participate in the energy transition not just as buyers of clean electricity, but also as producers themselves.

Yet, such is not the case today. Two case studies cited earlier provide a stark contrast.

SACASOL took 12 days to get its 22-MWp solar power plant project approved by the DOE, a clear expression of political will by the government to hasten the energy transition to renewables. As the first FIT beneficiary, SACASOL will get paid 9.68 per kWh over a 20-year period for its electricity output.

The 5-kWp home PV system of Mike de Guzman took Meralco ten months to approve a “net-metering” scheme (which is not true net metering, as explained in Chapter 12), under which Meralco only paid de Guzman around 5.50 per kWh for the latter's excess electricity output. But when de Guzman had to buy electricity from Meralco, he had to pay around 10.00 per kWh during off-peak hours and 14.00 per kWh during peak hours.

In the Philippines today, the big players in renewables enjoy the kind helping hand of the government. But the small players are left to the mercy of utilities, some of which feel threatened as more of their customers get cheaper electricity directly from the sun or the wind and are therefore doing their best to put up artificial barriers the widespread adoption of distributed generation.

A big 22-MWp utility project took the DOE 12 days to approve and will get paid P9.68/kWh.

A small 5-KWp home project took Meralco 10 months to approve and will get paid P5.50/kWh, but Meralco will charge it P10/kWh off-peak and P14/kWh on peak hours.

Chapter 17
Utilities and self-generation

In many countries, utilities have been traditionally leery of, if not actually hostile to, renewable options with inherently variable output, like wind and solar. They generally prefer the consistent availability and steady output of conventionally-fueled power plants.

Thus, the renewables that usually made it to the energy mix in the past were hydroelectric dams, geothermal plants and biomass-fueled power plants whose steady outputs were very similar to fossil-fueled plants.

While many utilities today retain this attitude, an increasing number have embraced wind and solar, particularly once they are convinced that the economics do work out to their advantage. Thus, utility-scale solar and wind farms have become increasingly common in Europe—where Denmark and subsequently Germany took the lead—as well as in the US where states like California have adopted aggressive renewable targets. The hundreds of RE developers who applied to join the Philippine FIT system attest to the increasing acceptability of wind and solar farms for utility-scale generating plants.

Distribution utilities (DUs) have also preferred big projects to small ones. DUs are not afraid of big generation companies such as utility-scale wind and solar farms, because their generated output will be sold through the DUs anyway. Thus, the interests of these two big players more or less coincide, with the DU simply tacking on its charges over the "pass-through" generation charge of the RE project developer.

Small players are a different matter. Once their rooftop systems are installed, their consumption of DU-delivered electricity will start going down, reducing the sales of the DU. Thus, it is understandable that DUs would try to discourage self-generation by small players.

However, just like the central computing facilities of old who had no choice but to live with desktop computing, or the landline monopolies who had no choice but to live with mobile telephony, DUs will have to learn to accept and to live with rooftop solar. With PV systems getting cheaper every year, small players will increasingly occupy a larger role in the generation of electricity.

Where utility-scale solar farms are becoming financially viable, self-generation from solar power—solar selfies, so to speak—will even be more viable. Consumption at-source will always be ahead of utility-scale generation because the former practically eliminates the costs of transmission and distribution and avoids all the various add-ons to the final retail price of electricity. Let us list these add-ons in detail (taken from a September 2016 Meralco bill) to see what costs self-generation avoids:

Table 36: Non-generation costs that are avoided by self-generation

Non-generation Cost	Per kWh Charge (pesos)	Fixed Charge (pesos)	Remarks
Transmission	0.8219		
System Loss	0.4188		
Distribution Charge	1.3183		
Metering Charge, fixed		5.00	
Metering Charge, per kWh	0.3377		The utility's cost of reading a meter apparently increases for higher readings
Supply Charge, fixed		16.73	The distribution utility is charging customers for the "supply" of electricity
Supply Charge, per kWh	0.5085		
Lifeline Rate Subsidy	0.0715		
Senior Citizen Subsidy	0.0001		Senior citizens: apply for this subsidy!
Government Taxes (local franchise tax, Value-added taxes on the generation, transmission, system loss, and distribution charges and on the subsidies)			Total for 213 kWh consumption: ?173.31 Note: Government taxes the consumer for system loss and for subsidizing lifeline customers. VAT should be absorbed by the gencos and DUs, but they pass it on to consumers, who also pay their own VAT (see last row)
Missionary (for small island grids)	0.1561		This goes to Napocor, to subsidize small power utilities
Environmental Fund	0.0025		Environmental groups: tap this fund!
NPC Stranded Contract Costs	0.1938		The consumers are still paying for the past errors of NPC
FIT Allowance (Renewable)	0.1240		Raised from 4 to 12.4 centavos
VAT			VAT Sales: 164.18 Non-VAT: 235.52

Source: Meralco bill, September 2016

Excluding taxes, the fixed meter reading and the fixed supply charge, the non-generation charges add up to ₱3.9532/kWh which is one centavo larger than the generation charge of ₱3.9439/kWh. By generating one's own electricity—through rooftop solar, for instance—one avoids more than half the retail price of grid electricity. Given the chance, consumers will jump at this opportunity.

Because of its inherent advantages, self-generation of electricity—mostly through solar panels and possibly through wind turbines and microhydro in rural areas—is here to stay, regardless of the DUs' own wishes.

But the DUs should realize that when small players exceed their own requirements and start exporting their surplus to the grid, this surplus will not decrease DU sales, because it will register as consumption in other electric meters nearby. The DUs will therefore get paid their usual retail price of electricity including all the add-ons tacked on the electricity bill.

Under true net metering, the DU's administrative costs will not increase either, because the electric meter's forward and reverse movements automatically take care of crediting the exporters of surplus electricity and shifting the charges to their neighbors.

Can the DUs benefit from rooftop solar?

In fact, DUs can benefit from rooftop solar (wind turbines and microhydro, too).

They will, for instance, earn RE certificates to meet their legal obligations under the renewable portfolio standard (RPS) provisions of our RE law. If they exceed their RPS obligations, the DUs can also sell these certificates on the RPS certificate market, to be bought by other DUs that are unable to meet their RPS obligations.

DUs themselves can also set up solar PV systems in residential homes and commercial buildings as part of their "outside plant" capital expansion. They can use exactly the same leasing and PPA business models that solar start-ups like Solar Philippines have used to attract new customers.

Utilities can expand their capacity in smaller kilowatt increments, rather than larger megawatt increments.

These customer-sited PV systems can bring DUs several attractive benefits:

- Utilities can expand their generation capacity in kilowatt- instead of megawatt-increments, a wise move that reduces technological, financial and project risks significantly and avoids long-term technology lock-in.

- Because the generated electricity is consumed at source, this helps reduce system losses, including transmission, distribution, transformer and other heat losses. It also reduces capital expenditures, as consumption-at-source does not require additional investments in transmission and distribution lines.

- Expansion in small increments does not require additional static and spinning reserves (generating plants that can supply electricity at moment's notice, if a big generating plant unexpectedly goes down.)

These and other benefits of incremental expansion are discussed more thoroughly in Chapter 16.

Self-generation through cheaper and cleaner renewables is a trend that DUs cannot stop. Logically, therefore, once small players install their own generating facilities on their rooftops, DUs would prefer that small players become large enough as quickly as possible, so that these small players can generate more electricity not just for their own use, but also for export to the grid. This way, solar selfies with surpluses will be benefitting DUs too.

Unfortunately, many DUs do not as yet see it this way. They still respond to small players with a knee-jerk response and put up all kinds of barriers to the latter's participation in the energy transition to renewable electricity.

Already, by generating and selling power right at the customers' premises, companies like Solar Philippines are taking market away from DUs like Meralco.

It simply needs a change of mindset among utility planners and engineers to realize that they can do the same, and possibly keep their customers. If utilities like Meralco generate electricity in their customers' premises—or even outside these premises, but putting solar panels on their electric posts for instance—they would save on various costs, and they can share their savings with their customers. Only by sharing, and offering better deals than upstarts like Solar Philippines, can utilities hope to keep their markets.

By generating and selling power at the customers' premises, companies like Solar Philippines are already taking market away from utilities like Meralco.

Chapter 18
Energy transition: Why is it taking too long?

If we have more than enough physical resources to tap, if renewable projects are now within the range of financial viability, and if business models now exist that solve the problem of high upfront costs, then why are coal and oil power plants still in the planning stages and in the project pipeline? Why are not more solar, wind, hydro and other renewable projects in the pipeline? What is keeping us from making the energy transition to full renewability?

We will try to answer these questions in this chapter.

The barriers to full renewability can be roughly categorized into the following:

1. *Lack of physical resources.*

While we have shown in Chapter 3 that we have enough renewable resources nationwide to meet our electricity needs many times over, we have also seen how these resources are unevenly distributed in the country.

Thus, some locations may not be as well-endowed as other locations. Geographic features such as mountains may cause obscuring clouds to appear more often and block out more sunlight. Others may disrupt wind flows and cause turbulence, making it harder to harvest electricity from the wind. In flat areas, it will be harder to find water systems that can be exploited for hydroelectric generation. Biomass generation will depend on the steady availability of biomass for fuel, and some areas may simply not have enough biomass to support a biomass-fueled generating plant. In addition, using biomass for fuel competes with its use for compost in food production.

The solution in such cases will be to import electricity from nearby areas better endowed with renewable sources. Given that we can be self-sufficient in renewable electricity nationwide, possibly even region-wide, the less endowed areas should not have to look too far to import electricity. This is no different from what we do today, when we construct plants at the hundred-megawatt and gigawatt levels. These plants are so widely spaced apart that they have to export their output to distant, less endowed locations too.

Transporting electricity to localities in need requires transmission and distribution lines. Thus, even where renewables make it possible for more households and communities to consume electricity at the point it is generated, we would still need a transmission infrastructure to support the electricity requirements of less endowed localities.

The need for transmission lines is even greater as we become more dependent on wind and solar. Given their inherent variability in output, even well-endowed areas will occasionally need to import electricity from neighbors when their sources are producing less than the current demand.

2. *Renewable electricity is too variable and cannot be used for baseload plants.*

The importance given to baseload plants—plants that provide a steady output 24/7—is an outdated idea. It was useful in the past, when renewables were very expensive, but it is less useful today, in a era of cheap renewables. It is possible to cope with the variable output of solar panels and wind turbines, in the same way that banks cope with the inherent unpredictability of deposits and withdrawals. There are technical, structural and social solutions, which are discussed more thoroughly in the next chapter.

3. *Renewable electricity is still too expensive to compete with fossil-fuels.*

This might have been true until a few years ago. But it is not so true anymore today, as Energy Secretary Petilla himself has realized and as we have shown in various case studies as well as calculations in this study. And it will become more glaringly false in the future. We have already shown how rooftop solar cheaper than grid electricity in most parts of the Philippines today. Of course, if consumers still mistakenly think otherwise, then the market for renewables, especially for PV systems, will remain sluggish.

What is needed at this point is for the policy makers, academics, and media as well as the public to be better informed about the state of prices in PV systems. This is something that can be done by suppliers who market their systems, by independent studies like this one, and by the government. Unfortunately, too many policy makers, academics and media people still mistakenly think that “solar is expensive”.

4. *The upfront costs are still too high*.

This was probably true until recently, when innovative financing approaches like solar power purchase agreements (PPAs) finally made their way to the Philippines. It is still partially true today, because only one company so far is engaged in solar PPAs, that company may not be fast or big enough to service the pent up demand for cheaper electricity, and its innovative approach excludes households and small businesses.

But it won't be long. The success of Solar Philippines can be expected to attract businesses to use its business model. Then, some can hopefully focus not only on malls but also small players. The market is big enough to support several more PPA-type operations.

5. Artificial barriers to the adoption of net metering.

The absence of true net metering is one of the worst barriers to the wider adoption of RE in the Philippines, especially among small players. It is one of the biggest flaw in the government's RE strategy. This problem is fully explained in Chapter 12.

6. *Ignoring households and small businesses.*

The government should realize that households and small businesses—the small players, who directly consume most if not all of their production—are the most efficient among RE producers, for reasons explained in Chapter 16. Unfortunately, small players have been left to fend for themselves in the market, while big players have gotten most of the attention and focus. Small players are out of the FIT system entirely. The small players' best option, net metering, has been mangled in favor of utilities instead. The provisions in the 2008 Renewable Energy Act which small players can take advantage of remain lacking in implementing rules and regulations.

7. *Slow government response to urgent issues.*

A good illustration of the slow response is the grid interconnection problem. The first solar utility company to qualify for the FIT is SACASOL. During a workshop on renewable energy sponsored by GIZ in October 2014, the SACASOL representative complained that they had been ready to connect to the grid since May 2014. However, the NGCP would not allow them to do so, because there was no risk analysis yet done on the impact of a 13-MWp solar facility on the stability of the grid.

One can just imagine the dismay of the SACASOL project developers. They had gone through the hoops, applying to the DOE, getting the necessary 120 signatures, gathered the investors, the financiers, and worked out the thousands of little details involved in such a huge undertaking. They had already invested nearly ₱2 billion into the project. They had been ready since May 2014 to supply clean, renewable solar electricity to the grid. Yet, no cash was flowing after four months of waiting, because the NGCP had done no risk analysis of SACASOL's entry into the grid. Had not the DOE announced its 50-MWp solar target more than a year earlier?

In 2016, the government has been talking of *curtailing* the output of solar farms in Negros. This means that two years after the lack of transmission facilities delayed SACASOL payments for months, the lack of transmission lines remains a festering problem.

The government's perspective

The government's perspective is very different. Because it is focused on the FIT as a means to encourage RE development, the government attributes the slowness of the energy transition to such things as uncertain approval by the National Commission on Indigenous Peoples (NCIP) and problems with local government permits and licenses. In short, local and social acceptability.

This was the opinion of DOE-REMB Director Mario Marasigan who cited as example the issuance of local licenses and permits. He has received complaints, he says, that up to 165 signatures were needed to get local approval.

In a June 2014 interview, the REMB director admitted that "more than 50%" of the 500-plus RE project applications were bogged down in problems involving local permits and licenses, including approval from NCIP. (At the Clean Energy Forum sponsored by the Asian Development Bank in 2016, another RE developer counted "more than 400" total signatures required.)

The positive side, he says, is that 40-50% have hurdled these problems.

But this is not even the biggest hurdle of all, Marasigan says. Marasigan cites as the biggest hurdle the non-cooperation of NCIP, their concept of “ancestral domain” and conflicts over land that this has generated. The contested area can be much larger than the 30% of the country that is already covered by ancestral domain claims, the REMB director says. He quotes NCIP's argument that indigenous peoples usually move from place to place as part of their culture and life style. Thus, if an IP is sighted near an RE development site, “the project is in trouble,” because that locality could turn out to be part of their ancestral domain. “It could take years” before NCIP can give its approval, he says.

As an indication—perhaps also a cause—of the problem, the NCIP is not a member of National Renewable Energy Board. It is only invited to attend meetings as an observer.

From Director Marasigan's perspective, the most important role that NGOs can play is in facilitating social acceptability. NGOs, he says, can help explain RE projects to local communities, LGUs and NCIP.

Truly, social acceptability is important. It would even be better if social participation became more widespread, by opening the doors wider for small players to join the energy transition to renewable electricity—not just as consumers but as producers themselves.

Without the participation of small players, the energy transition will indeed take too long.

Energy planning for the transition to a fully renewable future needs more than small players though, as the next chapter will explain.

Chapter 19
Energy planning needs a conceptual overhaul

Except for an enlightened few, most of the current crop of energy planners in the country still cling to the old conventional planning wisdom that is focused on power plant categories called “baseload”, “midrange” (or “mid-merit”), and “peaking”.

Baseload plants provide a steady output non-stop, 24/7, except when under maintenance. Shutting these plants down and then bringing them up to full capacity again may take several days to a few weeks. Peaking plants can be shut down or brought up to full capacity in a matter of hours or even minutes. The midrange plants lie somewhere in between.

We are now entering a new energy era, however, which is marked by the increasing deployment of a new type of power plant that is neither baseload nor peaking.

For planners to cope with this new era, the conventional wisdom in energy planning needs an overhaul.

The zero-marginal-cost power plant

Typified by solar and wind power plants, this new type of power plant is the zero-marginal-cost renewable plant. Because of their inherently variable output, these plants are often referred to by modern planners as variable renewables. To stay relevant in this new energy era, our energy planners must overhaul their own thinking, junk the old conventional wisdom about baseload plants, and learn to deal with this new type of power plant.

Variable renewables like solar and wind are increasing in importance for several reasons:

1. They rely on essentially inexhaustible energy sources, enabling countries and localities to enjoy better energy security;

2. They generate electricity in a relatively clean and climate-friendly way, in contrast with the harmful emissions of fossil- and nuclear-fueled power plants;

3. They use no fuel and therefore enjoy very low running costs (in economic terms, they are zero-marginal cost plants).

And because power plants are put online based on "merit order"—the lowest marginal cost plants first and the highest ones last—solar and wind plants enjoy "priority dispatch". In an era of cheap renewables, the low-marginal-cost output from variable renewables will get higher priority than the high-marginal-cost output of baseload fossil-fueled plants. This is why solar and wind power plants have been increasing in importance as the cost of building them have gone down.

The output of variable renewables cannot be controlled—the sun may be covered by passing clouds or the wind may stop blowing. Thus, a second type of power plant also becomes essential in the new energy era.

The flexible power plant

The flexible power plant is one whose output may be ramped up or down under operator control very quickly, in a matter of minutes or even seconds. Flexible power plants today include gas turbine plants, hydroelectric plants, batteries and other emerging storage technologies.

A single wind turbine will provide a variable output depending on changes in wind speed and direction. A single refrigerator acts as an intermittent load, as its rheostat turns the compressor motor on or off in response to temperature changes. When a large number of sources and loads are interconnected, however, the abrupt changes in the individual components of the grid are evened out, resulting in slower and smoother variations in power availability and consumption throughout the system.

Nonetheless, the combined output of solar and wind plants connected to the grid is weather-dependent and therefore inherently variable, although improved forecasting methods may reduce the unpredictability of these inherent variations. Similarly, the overall demand for power from the grid is also inherently variable and to a significant degree weather-dependent too.

The supply and demand for power must remain equal at all times. Small departures from this equilibrium will lead to gradual overheating of equipment and electrical lines. Big enough, they can cause protective devices to trip, disconnecting sources or loads from the grid and causing grid instabilities and power outages.

The role of flexible plants is to ramp up or down their output and shape the total on-grid power output. The goal is to ensure near-instantaneous tracking of the total on-grid demand.

The micro-scale power plant

Another way to deal with the variability of solar and wind is to deploy thousands, even millions, of small units that generate their output at the kilowatt level. At this scale, the problem of variability can be much more easily handled because it becomes statistically predictable. On the demand side, most of the loads on the grid are in fact micro-scale, mitigating the intermittency of most air conditioning, refrigeration and industrial loads.

This micro approach has an even more important consequence. It can also activate economies of scale—as can already be observed in the solar PV sector—which can further bring down the cost of renewables and possibly launch virtuous cycles of increasing production and declining prices similar to those which earlier triggered the computer, telecommunications and information revolution.

In an era of cheap renewables, power plants which have neither flexibility, low marginal costs, nor micro-scale outputs—like coal-powered plants—will have very little role to play. A country like the Philippines that, at the threshold of this new era, locks itself in to such an outdated technology will saddle itself with dirty and increasingly expensive plants that will eventually have to be phased out much earlier than their design life.

The baseload capability to maintain steady output 24/7—as a nuclear power plant does—will not be a major asset in the new energy era. In the first place, a fixed output can be easily simulated by combining variable plants with a flexible plant that evens out the crests and troughs in the variable output, to achieve a steady combined output. More importantly, a fixed output in itself is incompatible with demand on the grid, which varies significantly over a 24-hour period. Thus, a baseload plant needs a flexible complement as much as zero-marginal cost variable plants like wind or solar.

Unfortunately today, the outdated baseload concept persists as a mindset not only among energy planners but also among academics who critique the government's energy plan. Because these critiques are still based on the baseload concept, they continue to reserve a place in the electricity mix for power plants that can provide steady output 24/7—ensuring a significant share in the electricity mix for coal, if not nuclear.

Energy storage facilities

The fourth type of power plant that will play an important role in an era of cheap renewables is the battery and other energy storage facilities. Energy storage is important particularly for variable, zero-marginal cost renewables, whose outputs are dependent on weather conditions. They will enable users to store energy during periods of high output (midday sun on cloudless days, or high winds) and retrieve the stored energy during periods of low output.

The two most common storage battery technologies in use today are lead-acid and lithium technologies. Lead-acids will add around ₱30/kWh to the cost of electricity. Lithium batteries will around ₱10 to ₱20/kWh, depending on the battery's life-cycle. Claimed life cycles for lithium today range from 2,000 to 10,000 cycles, but because the technology is relatively new, it is too early to determine how valid the higher claims are. Once solar LCOE reaches around ₱4-5/kWh and battery LCOE around ₱5-6/kWh, their combination will become competitive with grid prices. This is expected to happen in five years, by around 2020. Already, lithium technologies are showing the same virtuous cycle of exponential decrease in prices and increase in production levels that have characterized other products where economies of scale have been activated.

Aside from batteries, pumped hydro is also a mature large-scale energy storage technology that is already in deployment.

Newer technologies are also actively being sought and explored, because three major industries are heavily dependent on energy storage: the electric vehicle industry, the computer and communications industry, and of course the renewables industry. Some of these are already in commercial deployment. The long list includes flow batteries, compressed air energy storage, supercapacitors, flywheels, fuel cells, and others.

In the future, the wide deployment of energy storage will settle any lingering debate about the central role of variable renewables in energy systems.

"Negawatt" power plants: energy-efficient electrical devices

A fifth type of power plant will play a significant role in the coming era. This type is, strictly speaking, not a power plant at all. The power it generates is measured in "negawatts", or megawatts saved rather than produced. It does make sense, however, to think of LED lamps and inverter-type aircons/refs as power plants, because by reducing the amount of power that goes to waste, they then make this power available for other uses *as if* they had produced this power themselves.

A huge body of literature can be found on the Web on energy efficiency and demand-side management (DSM), an aspect of energy planning that was pioneered by physicist Amory Lovins.

In essence, this approach involves the deployment of technologies that provide the same level of energy service while using less electricity. An investment in the technology therefore retains the same level of service—whether it is the amount of lighting or the temperature reduction required—while resulting in a permanent power savings. The power saved (the "negative watts") can then be used to provide other energy services, as if the power had been generated in a power plant. Thus, the levelized cost of electricity (LCOE) from such energy efficiency measures as shifting to LED lighting or to an inverter-type aircon can also be calculated and compared with supply-side measures that involve actually building a new power plant.

And invariably, it turns out, the energy efficient demand-side approach costs lower than the supply-side approach. It is almost always cheaper to save electricity by making more efficient use of it, than to generate more electricity by building new power plants.

After you replace a 75-watt incandescent lamp with a 15-watt LED lamp at a cost of, say, 300 pesos, you will be saving 60 watts every time you turn the lamp on, throughout the lifetime of the lamp. If the lamp is good for 5,000 hours, this means 300,000 watt-hours (300 kWh) saved. Given the 300-peso investment, this means one peso per kWh saved, which is far lower than the 8-12 peso per kWh retail price of electricity in the Philippines.

It is also important to distinguish between energy-efficiency measures such as replacing an incandescent with an LED lamp, and energy conservation campaigns such as switching the lights off in unoccupied rooms and similar behavioural changes in the consumer.

Investing in a campaign to change consumer behaviour may result in similar low-cost savings per kWh. However, we are not sure whether the behavioural change attained will last for five years, five days, or anything in between. Thus investments in such campaigns have to be evaluated carefully, to determine how cost-effective they really are compared to measures with provably longer-lasting impacts.

Midday peaks are generally caused by air-conditioning loads, and night-time peaks by lighting loads. Thus energy-efficient lighting, air conditioning and solar rooftops all have a significant role to play in reducing peak demand and the need to build new power plants.

The energy infrastructure of the future

The grid of the future will rely mainly on five types of energy sources:

1. The low/zero-marginal cost plants that require no fuel, which will supply the bulk of our electricity at very low cost;

2. The flexible plants, whose outputs can be varied quickly, to shape the total supply output in accordance with the requirements of demand and to ensure balance within the system between supply and demand;

3. The micro-scale plants, with outputs in the kilowatt rather than megawatt range, which will bring in the benefits of distributed generation and enable ordinary citizens to participate in the great energy transition not only as consumers but also as producers of renewable electricity themselves;

4. Energy storage facilities, which will store energy during periods of high supply and low demand, and retrieve them for use during periods of low supply and high demand; and

5. Energy-efficient devices which make available cheap power by harvesting power that would otherwise be lost in inefficient and wasteful devices.

Energy efficiency, solar, wind, and—soon—power plants driven by ocean waves or tidal currents will comprise the low/zero-marginal cost infrastructure, which will ensure that consumers of the future will enjoy the benefits of electricity at a low cost.

Hydro and biomass will provide the flexibility that will ensure grid reliability by providing a total supply that is equal to the demand at all times. As energy storage technologies become commercially viable, they will play an increasingly bigger role in providing flexibility in grid supply.

Solar and wind farms and mega-hydro projects may be renewable, but each installation will cost hundreds of millions, if not billions, of pesos. These projects can only be undertaken by huge multinational firms or the national government, and the only role that ordinary citizens can play in these projects is as buyers of electricity.

Rooftop solar, microwind, microhydro and small biogas plants will make distributed generation a practical reality. They will enable the ordinary citizen to participate in the renewable energy revolution not only as consumers but as producers themselves of electricity.

Cheap solar panels and inverters are already making the household generation of electricity affordable today. Things will even be better in the future, as solar prices continue to drop and if similar economies of scale take effect in the microwind and microhydro sectors as well as the energy storage sector.

Just as microcomputers sidelined the mainframe, and cellphones sidelined the landline, microgeneration through solar, wind, hydro and biogas plants together with cheap energy storage may eventually sideline the big power generation companies and transform the grid in a fundamental way. The "mainframe" energy facilities will be sidelined by millions of micropower plants owned and operated by consumers themselves.

The grid will not by any means disappear, because interconnectivity brings inherent advantages compared to stand-alone operation, as the Internet clearly shows. But its nature will change. Most households will in the future become empowered to generate their own electricity. They will use the grid mostly to share their excess production (to sell it, to accumulate credits for later use, or possibly even give it away just as people freely give away information on the Internet), or to buy some if their production is not enough. They should be able to choose the source of the electricity they are buying—a friend with an extra-large set of solar panels, or a community-run microhydro installation.

Under such a scenario, as our society gets better in extracting cheap, clean electricity from renewable sources and from otherwise wasted energy, we can all hopefully begin to enjoy the promise of energy security, energy democracy and energy abundance that respect people's health, the environment and the climate.

In this book suggests two innovative approaches in national planning for the electricity supply.

The first approach is to adopt an intermediate goal that is focused on new supply requirements, taking the existing and committed supply capacities as given (see Chapter 4). In the context of the Philippine Energy Plan 2012-2030, it turns out that applying this approach would have resulted in a remarkable conclusion: the government's own energy efficiency and renewable energy targets were more than enough to supply all new demand with 100% renewable electricity. Had the government worked really hard to attain these energy efficiency and renewable energy targets, there would have been no need—since 2013—to build new fossil-fueled power plants.

The second approach is to leave behind the outdated concept of baseload plants, and focus instead on new types of power plants that are more appropriate in the new energy era: zero-marginal cost plants, flexible plants, micropower plants, energy storage facilities, and negawatt plants.

The incoming Duterte administration needs only to embrace these two approaches to make a giant step towards the energy transition to a renewable future.

Chapter 20
Dealing with variable output: energy storage

The variable nature of solar and wind resources is often used as argument against renewable energy. Their unpredictability, the argument goes, means they cannot be relied on to provide the electricity when it is needed. Thus, the argument says, we need fossil-fueled (or nuclear) plants as back-ups, to ensure that we have electricity when we need it.

It is possible to deal with variable output.

Rain, wind and sunshine in a particular place can be compared to bank depositors, who also behave individually in variable and unpredictable ways. But, like wind and sunshine, their behavior over longer periods of time can be characterized. And this can be known with sufficient statistical certainty, that banks can—and actually do—bet their money on this knowledge.

Wind, sunshine and rain in a place are like bank depositors. Individually, they behave in variable and unpredictable ways. But their behavior over longer periods can be characterized with enough statistical certainty to bet our money on.

When banks face heavier withdrawals than usual, they can borrow cash from other banks, to enable them to meet the unexpected demand. Thus, heavy activity in some areas and sluggish activity in other areas tend to even out over a larger area, as long as enough secure transport is available to move cash back and forth. This is also true among renewable producers, whose variable outputs will tend to even out over a larger area, as long as enough transmission lines are available to move electricity back and forth.

Another approach in coping with variability is to diversify sources to even up the peaks and troughs of their individual outputs. In many places, wind speeds approach their highest around sun up and sun down, nicely complementing solar power, which peaks around noon. Micro-hydro installations can provide the steadier output, and biomass output can be on-call.

And in those not-so-common instances when depositor behavior departs radically from their expected statistical behavior, a central bank steps in to soften the impact of such outliers, and in the worst of cases, insurance companies — truly the last resort — pick up the pieces.

Solar and wind energy also need banks of storage devices to hold excess production, when demand falls below their output, and to release the stored energy, when demand shoots up. Energy storage is a technological requirement and technologies have been, and continue to be developed, to keep pace with the storage requirements of variable energy sources. These include pumped storage of water, compressed air storage, battery banks and the production of hydrogen and synthetic methane. As solar and wind energy take the center stage, more storage options are expected to emerge.

Pumped water storage

In the US grid, for instance, pumped water storage composes 95% of the grid's total storage capacity. Pumped water storage is a mature technology. In the Philippines, a 390-MW pumped storage facility is now underway in Ifugao, to be supported under FIT once it goes online. (Michael Harris, "SNAP-Ifugao remains committed to developing 390-MW Alimit hydropower project in Philippines", HydroWorld.com, 8/29/2016, http://www.hydroworld.com/articles/2016/08/snap-ifugao-remains-committed-to-developing-390-mw-alimit-hydropower-project-in-philippines.html)

During off-peak hours, when the output of all operating plants may exceed the demand, the surplus electricity can be used to activate pumps to force water up for storage in an elevated water reservoir. During peak hours, the reservoir can channel more water into its turbines, and increase its output within minutes.

The other 5% of energy storage facilities in the US grid consist of flywheels, compressed air, thermal storage, electrochemical capacitors and various battery-based storage.

Flywheels

In the case of flywheels, electricity is converted to and stored as rotational energy. Giant flywheels, large enough for utility-scale applications, are now being used to even up the highs and lows of power flow. As high as 3 MW of these flywheels have been used for frequency regulation, and 20-MW sizes are have been tested in New York and Pennsylvania.

An example of a commercially available flywheel storage is the one-ton Beacon Power's "Smart Energy." Its 25-inch diameter flywheel can exceed a rim speed of 2,400 kph and store 25 kWh of electricity, more than enough for household use. A 20-MW array of 200 such Beacon Power flywheels was recently installed in Stephentown, New York, for storing up to 5 MWh of electricity.[103] This was followed by a similarly-sized plant in Pennsylvania, which went into full commercial operation in July 2014. For comparison, flywheels have charge-discharge cycles of 100,000-175,000, compared to 1,000-10,000 cycles for storage batteries. Another company, Amber Kinetics, produces a similar 20-MW flywheel storage plant. Amber Kinetics was negotiating in 2016 a larger 30-MW system with another Pacific Rim IPP. ("Amber Kinetics signs 20 year ESA with PG&E for 20 MW flywheel storage system", Stratton Report, 1/20/2016, http://strattonreport.com/news/amber-kinetics-signs-20-year-esa-with-pge-for-20-mw-flywheel-storage-system/)

103 Richard A. Muller, *Energy for Future Presidents: The Science Behind the Headlines,* (New York: W.W.Norton and Company, 2012), p. 175.

Compressed-air energy storage

Compressed-air energy storage (CAES) involves using surplus electricity to pump compressed air into a sealed geological formation like an abandoned mine or a salt dome. The compressed air can later be used to drive turbines to generate electricity. Compressed-air storage facilities are already operating in the US and in Germany.[104] A 290-MW CAES plant has been operating in Huntorf, Germany since 1978, and a 110-MW CAES plant in Alabama, US since 1991. (Jeff St. John, "", Greentech Media, 7/9/2013, http://www.greentechmedia.com/articles/read/texas-calls-for-317mw-of-compressed-air-energy-storage2)

A CAES facility planned in Norton, Ohio consists of a huge cavity in an abandoned limestone mine, that will be able to store 2.7 GW.[105] Texas is also planning a 3-17-MW CAES facility.

Supercapacitors

Supercapacitors do not depend on chemical reactions, as batteries do, and can therefore store and release electricity much more quickly than batteries. And they last longer too. They are still more expensive than batteries at this time, though.[106]

Storage batteries

Storage batteries are now the center of intense research and development as three major industry clusters rely on batteries for power storage: the mobile computing and telecommunications industries, the electric vehicle industries ranging from golf carts to sports cars, and the solar and wind energy industries. The result of the synergisms in battery developments among these industry clusters is extremely rapid growth. Thus, the storage battery market is expected to grow from $200 million to $19 billion within five years, a phenomenal growth rate of almost 150% per year (a doubling of the market every nine months).

The requirements for storage systems of mobile devices and vehicles are very demanding. They need to store huge amounts while staying small and light, and they will be subject to extremes of environmental conditions. Such storage systems are one of the areas of interest of intensive research today. Renewables will be getting a free-ride on these research efforts, because storage systems which fail to meet the stringent requirements of mobile and transport applications may still serve perfectly well for home storage applications.

The lithium-ion battery commonly found in low-power applications such as mobile phones and laptop computers has also been used in electric vehicles and power utility storage systems. A Massachusetts-based company called 24M says they will soon be able to deliver "1 megawatt of power over a four-hour period from a battery the size of a small walk-in closet."[107] In what is probably the largest lithium-ion battery bank planned so far, Edison of Southern California has embarked on a seven-year project to build a huge bank of lithium-ion batteries with a total capacity of 400 MWh of electricity.

Newer battery technologies include flow batteries, whose capacity are only limited by the size of the tanks that contain the electrolytes used; molten metal batteries which operate under temperatures high enough to melt metals; and zinc-air batteries.

104 Warburg, p. 178.

105 Muller, p. 172.

106 Muller, p. 176.

107 Warburg, p. 178.

A promising battery technology based on molten metal is the sodium-sulfur battery. A 4-MW version has been installed in Presidio, Texas, which can supply its rated capacity for eight hours. A larger 36-MW version is being planned for the Notrees Windpower Project, also in Texas. Current designs can last for 4,500 charge/discharge cycles, while lithium-ion and lead-acid batteries are usually only good for more than 500 cycles.[108] Molten sodium, however, has a temperature of around 350° C, requiring special handling.

In the future, a parallel shift from fossil-fueled to electric vehicles will perfectly complement the growth of solar and wind electricity. Since most private cars are idle much of the time, they can in their idle periods be connected to the grid, not only to recharge their batteries from the grid but also to *feed in electricity from their batteries to the grid*. They can actually *sell back* electricity to the grid, if the electricity from their battery banks will be less expensive than electricity generated from fossil-fueled peaking plants. Obviously, the economics of these will have to work themselves out, but when electric cars reach millions, their combined storage capacity will in fact be equivalent to several utility-scale power plants. It will therefore make economic sense to tap this idling storage capacity.

Vehicle operators could be earning money not only when they are moving passengers but also when they are plugged into the grid.

Currently, the few utilities that currently have a net metering scheme will not let consumers participate in the program if the consumer's renewable setup includes a battery. This institutional barrier to entry is apparently meant to prevent an arbitrage situation where the consumer buys cheap electricity from the utility during off-peak hours, stores the electricity in batteries, then sells it back to the utility during peak hours at a higher price—for a profit. They apparently do not want their customers to make money on them, a knee-jerk reaction that has been commonly observed in many utilities in other countries.

In fact, when utilities act this way, they are going against the interests of their own stockholders. Arbitrage is an established, legitimate market mechanism. If utilities are willing to buy peak-hour electricity from diesel- or gas-fueled peaking plants at more than ₱20.00 per kWh, why should they refuse to buy from their own customers at say ₱12.00 per kWh and save ₱8.00 per kWh? It makes economic sense to do so, even if the electricity they are buying originally came from the utilities themselves.

The utilities must abandon this knee-jerk reaction and adopt the perspective that they are outsourcing peak-electricity, which can come from peaking-plants that generate the electricity at peak-hours, or from service providers that sell storage facilities for utilities. In the latter case, the utilities are actually outsourcing storage services. As more and more renewables based on solar and wind come online, given their inherently variable output, a new market for the storage of electricity will emerge.

This is where electric vehicles come in. Once e-vehicles are deployed in millions, their batteries can doubly serve as storage facilities for the variable output of renewables.

In fact, the frantic research for electric storage facilities suitable for mobile applications (from cellphones to electric vehicles) can produce batteries which may not be light enough for

108 Muller, p. 168.

portable use, but will make perfect storage for stationary applications in solar PV and wind systems.

Once e-vehicles are deployed in millions, their batteries can doubly serve as storage facilities for renewables.

The introduction of the electric car Tesla Roadster in 2008 was a landmark not only for electric vehicles, but also for the use of batteries in high-powered applications.[109]

Already, a new business model is now being tried, in which gasoline stations will be replaced by "battery stations" where e-vehicle owners can take newly-charged batteries in place of their discharged batteries.[110] All these batteries are potentially useful too for smaller scale solar and wind facilities.

Every new development in batteries for e-vehicles will benefit the renewable energy industry. In fact, even before batteries become practical for e-vehicles, they will already be useful for solar and wind applications.

In this regard, renewables and e-vehicles have a common future.

Structural approach: A very different energy system and energy market

In 2013, a German think-tank, Agora Energiewende, published a highly influential discussion paper.[111] The paper explored the key challenges for Germany's power sector, which was slowly but surely shifting to renewables, mainly solar and wind. Their conclusion: among the various potential sources of renewable electricity, wind power and photovoltaics were "the most cost-effective technologies with the greatest potential in the foreseeable future." The study noted that the costs for wind systems have fallen by 50% since 1990 (3.1% per year), while photovoltaic systems costs have fallen by 80 to 90% over the same time period (~8.3% per year), "with no end in sight." Other technologies (water, biomass/biogas and geothermal) were either "significantly more expensive" or had "limited potential for further expansion."

This section is a summary of the twelve insights in the Agora study:

1. **"It's all about wind and solar!"** The study concluded that wind and PV power were "the two essential pillars" of Germany's transition to renewable energy. The paper noted that as energy sources, wind and photovoltaics were "fundamentally different" from fossil fuels because of their inherently variable output and their high capital costs but extremely low operating costs. For solar, it was 1–1.5% of capital costs per year, while for wind, it was 2–4% of capital costs per year. Thus, the paper concluded that these fundamental differences will "profoundly alter the energy system and energy market."

   Agora suggested that "wind and PV power should be expanded in tandem since they have mutually complementary features; generally speaking, the wind blows when the sun is not shining and vice-versa." Even if Germany's north is better endowed with wind, and its south is better endowed with sun, "wind power should not be generated exclusively in Northern Germany, and solar power should not be generated only in Southern Germany." Spreading out the different generation facilities is better for optimizing the system as a whole, the study said.

109 Yergin, pp. 697-698.

110 Yergin, p. 698.

111 Agora Energiewende, "12 Insights on Germany's Energiewende: A Discussion Paper Exploring Key Challenges for the Power Sector," Berlin, February 2013

2. **“'Base-load' power plants disappear altogether, and natural gas and coal operate only part-time.”** Germany's future energy system, the paper asserted, will be based mainly on wind and PV, and the rest of the system will be optimized around the two. “Most fossil-fueled power plants will be needed only at those times when there is little sun and wind, they will run less hours, and thus their total production will fall. Other technologies like combined heat-and-power as well as biomass plants will also be operated similarly—at those times when there is little sun and wind. The inherent variability of wind and PV will therefore “create new requirements for both short- and long-term flexibility.”

3. **“There's plenty of flexibility—but so far it has no value.”** Technical solutions already exist for various technologies to meet these new requirements for flexibility. By flexibility, the paper means *quicker* in handling start-up times, minimum loads and load fluctuations. But since flexibility has little market value so far, the paper says that “the challenge is not about technology and control, but rather about incentives.”

4. **“Grids are cheaper than storage facilities.”** This is the paper's conclusion, after comparing the two possible approaches to flexibility. And this is true both at the transmission and distribution levels—at least with current prices and costs. The paper makes clear, however, that part of this conclusion is based on Germany's access to the European grid. In the Philippine case, we will need to review carefully the necessary balance between grid and storage.

5. **“Securing supply in times of peak load does not cost much.”** Agora also acknowledges that this insight is based on Germany's access to the whole European grid. In our case, peaking plants usually charge a huge premium for their services.

6. **“Integration of the heat sector makes sense.”** Because heat is easier to store than electricity, bringing in the heat sector eases the overall problem of energy storage for the whole system. This is especially relevant in countries like Germany, where winds blow hardest during the winter months and where there is significant demand for both process and space heating.

7. **“Today's electricity market is about trading kilowatt hours—it does not guarantee system reliability.”** Today's markets ensure that the output from the lowest-cost power plants are dispatched first, followed by the next lowest-cost, and so on, according to their increasing cost, until the entire demand is met. The market price is set by the marginal supplier (the latest to be dispatched, which is also the most expensive one). Under this mechanism, the plants with the highest cost will be dispatched last and will earn the least, even if they are essential for covering peak demand. As they will probably operate for only a few hours per year, their profitability will be at risk. The problem will become worse as the share of cheaper renewables in the energy mix increases, causing the average price to go down further.

   This is one of the biggest challenges of the new energy market based on wind and sun: how to ensure profitability for these marginal plants that will operate for only a few hours per year.

8. **“Wind and PV cannot be principally refinanced via marginal-cost based markets.”** While economic theory prescribes marginal cost pricing, “wind and PV produce electricity when the wind blows and the sun shines, regardless of electricity price.” The two do not heed the price signals required by this approach and economic theory, that production should go down as prices go down. And because wind and sun do

not heed price signals, "in times when wind and/or sun is plentiful, wind and PV facilities produce so much electricity that prices decrease on the spot market, thus destroying their own market price." That is why they cannot be refinanced with marginal-cost pricing.

Agora states the fundamental market problem as follows: "Wind and PV cannot earn enough revenues to cover the average cost of their initial investment in the market, because the price will always be lower than the market price average whenever the wind is blowing or the sun shining, which is precisely when electricity can be produced from these weather-dependent technologies."

Agora's solution is in the next insight.

9. **"A new Energiewende[112] market is required."** This market will be designed differently—aside from its old function of balancing electricity supply and demand through price signals and marginal-cost pricing, it must also perform the new function of attracting the required investments for new plants, demand-side flexibility and storage technologies. Aside from its old revenue source of selling energy output (megawatt-hours), it must develop a new revenue source of selling energy capacity (megawatts).

   The new investment market for megawatts must reward reliable, flexible supply- and demand-side resources to guarantee system reliability. Flexibility means quick ramp-up and ramp-down times for both power stations and loads. The participation of energy storage systems in the market must also be enabled.

   The details of the new market's configuration must be further worked out. Agora listed several options, including premiums/bonuses, tenders/auctions, and certificates/quotas. The study made clear that the new market is a move beyond feed-in-tariffs, which have been the main drivers in the past of the renewable energy program of Germany.

   Agora emphasized that the participation of citizens as well as SMEs was essential in the past. It would again be essential for the new market.

10. **"The Energiewende market must actively engage the demand-side."** By improving demand-side flexibility, more wind and PV sources can be integrated into the grid without relying on expensive storage. For instance, how can users be shifted en masse from period of little wind and sun to periods of high wind or sun? Because of inelastic demand, prices signals such as time-of-use pricing have not been very effective.

    Where technological and behavioral approaches have worked, demand-side measures have invariably proven cheaper than supply-side or storage solutions. In many cases, some industry loads can be temporarily shifted without additional investment. Efficiency improvements in buildings can also reduce air conditioning requirements. Shifting to equally bright but cooler LED lighting can further reduce the air conditioning load, at the same time reduce electricity consumption, without sacrificing the lighting needs of building occupants. Demand-side participants should be able to participate more actively in bidding negative loads by eliminating onerous requirements. The next chapter covers this topic in more detail.

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112 Energiewende means "energy transition" in German.

11. **"The Energiewende market must be considered in the European context."** Its connection to the larger European grid gives Germany unique advantages that are not available to smaller grids like ours. Nonetheless, it is still useful to know that enlarging our national grid by interconnecting the Luzon, Visayas and Mindanao grids will also be good for renewables, among its other benefits.

12. **"Efficiency: A saved kilowatt-hour is the most cost-effective kilowatt-hour."** This lesson has been proven again and again in various countries. Energy efficiency and conservation are the cheapest ways to make available more kilowatt-hours to meet the increasing demand for various energy services. This is explained further in the next chapter.

Chapter 21
Can microrenewables lead to an energy revolution?

[This chapter reproduces the author's paper entitled “Virtuous Cycles of Expanding Production and Lower Costs Through Economies of Scale: Lessons from the Information Economy”. The paper was accepted by World Energy Congress (WEC) for presentation at the 23rd WEC in Istanbul on Oct. 9-13, 2016. It went through the usual anonymous peer-review process and was revised by the author several times before its final acceptance. Since the biennial congress is attended by heads of states, ministers and secretaries of energy, and the energy experts from all over the globe, the acceptance of this paper means that the ideas contained here are being taken seriously by international energy experts. Microcomputer led to the information revolution. Perhaps, microrenewables can lead to an energy revolution.]

1. Introduction

Renewable sources of energy such as the sun, wind, flowing water, hot underground rocks and biomass are highly preferred because they depend on local resources that are easier to secure; they are more environmentally benign and less harmful to human health compared to fossil-fueled and nuclear plants; and—except for biomass—they require no fuel and therefore incur very low marginal costs. Appropriately sized, they can be tapped directly by small communities and even households. Thus, renewables can help resolve the world's triple dilemma of energy security, environmental sustainability and energy equity.

The use of renewable energy can become more widespread by making them more affordable to ordinary people. Affordability was a major factor in turning oil into the dominant source of energy and power in the late 19th and the 20th century; affordability was also the factor that turned the small computer and its variants into the dominant tool of the 21st century [9]. This paper explores how renewables can attain lower costs and better affordability that can turn them into the dominant source of energy and power in the 21st century.

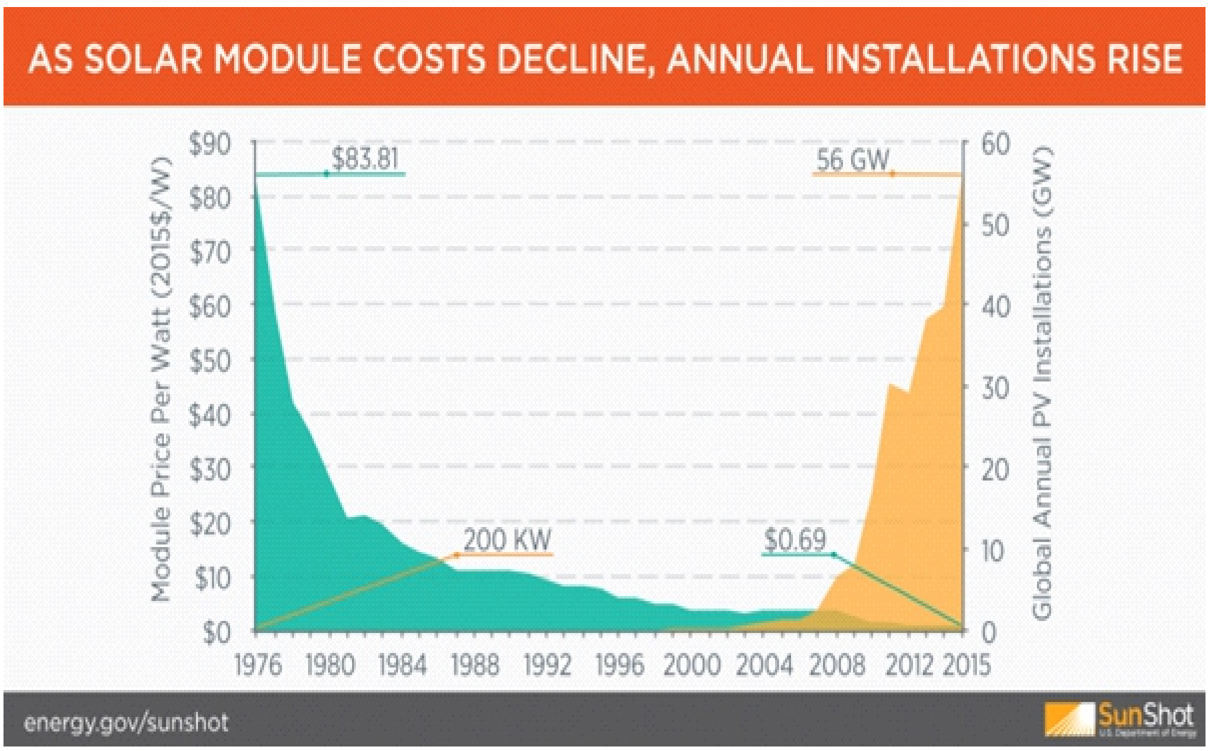
2. Attaining Economies of Scale

Affordability means a low price. Conventional economic wisdom asserts that low prices encourage consumption but discourage production, both of which exert an upward pressure on price. Thus a drop in price creates economic forces that tend to raise it back. This negative feedback creates a balancing mechanism towards an equilibrium point of price and quantity that tends to maintain itself.

Under certain conditions, however, the negative feedback can turn positive. Instead of tending towards an equilibrium of price and quantity, the feedback can lead instead to exponential growth in quantities traded, and exponential decline in prices.

This positive feedback can happen, for instance, when higher demand encourages greater production among suppliers, and the increased volume of production enables some suppliers to attain economies of scale. The economies of scale in turn allow them to maintain and even improve their profit margins through lower costs and higher sales. Under such conditions, producers who are able to take advantage of economies of scale can find themselves in a virtuous cycle of increasing production and lower costs, putting them in a position to bring down their prices further and keep the virtuous cycle going. Belatedly, economists have been looking at theories that analyze economies of scale, including the economics of increasing returns to scale [1].

Figure 12. The solar PV industry is showing a virtuous cycle of declining costs and growing markets



(*Image credit:* Earth Policy Institute/Bloomberg).

Such virtuous cycles of exponentially declining prices and growing markets can already be seen in the solar PV industry, as Figure 12 shows. [2]

It is easy to understand why small systems like solar panels enjoy economies of scale much better than big power plants like mega-dams or coal plants.

Coal plants come in sizes of 100-1,000 MW; big dams in 10-100 MW sizes. Solar projects use 100-250-watt panels for their building blocks.

Raising generation capacity by 1,000 MW would need 1–10 coal plants, 10–100 dams, or 4–10 million solar panels. In fact, because solar power plants generate in 24 hours only one-fifth the output of their conventional counterparts of the same capacity, some 20–50 million panels would be needed to provide the same amount of kWh that a 1,000-MW coal or hydroelectric plant will provide. Finally, since a typical 100-watt panel may consist of 72 individual solar cells, *some four billion solar cells have to be manufactured* to provide the same amount of electricity as ten 100-MW coal plants or one hundred 10-MW hydroelectric plants.

Clearly, the solar PV industry can benefit from learning curves and economies of scale in ways that are simply not possible when only ten or a hundred units have to be built. Decreasing costs are *inherent* in the technology of solar PV. [19]

The challenge for other renewables is how to attain market sizes large enough to trigger economies of scale that can bring about virtuous cycles similar to those we have seen in the computer industry, the Internet, and the solar PV industry.

This paper proposes the following measures learned from the information economy that the renewables industry can adopt in order to expand their markets and attain production levels that can realize economies of scale.

2.1. Downsizing

Downsizing means making smaller marketable units or building blocks that can be sold at lower prices. Scaling down towards smaller and lower-priced units creates new markets consisting of those who previously could not afford the higher price. Priced lower, they become affordable to more people. The larger market enables producers to expand production towards operating levels that allow mass production methods to be applied, bringing down their costs further. This in turn can make products even more affordable. Once economies of scale are activated, a virtuous cycle of lower prices and higher production becomes possible.

A simple example of this approach is the packaging of shampoo, toothpaste and similar products in small sachets to reach lower-income brackets. Downsizing, however, can go much further than this.

It was the downsizing of the mainframe computer to the mini-computer, and later to the microcomputer, that launched the computer mass market, which in turn made the global Internet possible. This process is not over yet, as CPUs, memories and storage continue to be downsized for the smartphone market. The resulting affordability of the microcomputer—and its various reincarnations—has made it a deep game-changer, by changing the rules of the game not only in the computer industry but also in the whole economy and in society as well. [20]

Downsizing should not be pursued for its own sake. It must be pursued if the smaller version results in a significantly lower-cost product. Lower prices result in larger markets, which require larger production volumes. The goal of downsizing is to reach production levels that activate new economies of scale, which lead to new rounds of price reductions—this time, not simply because of a smaller, lower-priced product, but because of higher productivity. Under the right conditions, the lower prices can trigger another round of market and production expansion, which can then launch a virtuous cycle of lower prices but greater production. This positive feedback process trumps conventional economic wisdom, which presumes negative feedback leading to an equilibrium of supply and demand.

Sizing Solar Panels

Scale economics is working well in solar production, as Figure 12 shows. In many parts of the Philippines, solar rooftops—which avoid the cost of transmission, distribution, system losses and other costs—are already the cheapest source of electricity today [19]. Rooftop solar will pass grid parity in each distribution utility service area over the next few years as solar PV costs continue their decline. Within a few years, rooftop solar will become the cheapest source of electricity nationwide. A similar trend can be expected in other countries.

Solar manufacturers already sell products based on the solar cell—the building block of solar panels, solar arrays and solar farms. Solar cells already enjoy the benefits of economies of scale. The production and price history of solar cells, in fact, already shows the recognizable features of an exponential rise in production and fall in prices—typical marks of the virtuous cycle we are after.
But the urge to upsize remains a temptation, like the mainframe manufacturers who sought growth by building super-computers.

Solar panel assemblers today, however, are starting to show a hint of the "bigger is better" bias. Solar panels are getting larger, and 300-watt panels are now being sold commercially. It is easy to imagine suppliers thinking of super-sized 500-watters down the line. Perhaps one-kW giants are already on the planning board.

Look on the other hand at the downscaling that computers went through—from mainframes to mini, micro, desktop, transportable, portable, laptop, notebook, netbook, tablet, embedded, etc. It is not hard to imagine, in the not-so-distant future, a similar transformation for solar, opposite today's trend.

This paper suggests that solar panels should be kept small and light enough for one person, working alone, to lift and carry comfortably. To keep within this limit, solar panels should stay below, say, one square meter in size. To get higher wattage, just use more panels or use more efficient ones. At two m^2, the 300-watt panel is definitely too big and too heavy for a single person to carry. These panels will require additional labor costs due to their unwieldy size. If solar suppliers want to reach the household market and its millions of rooftops, they had better stick to solar panel sizes that a homeowner, working mostly alone or with some occasional help, can comfortably lift, carry and install. Remember the "transportable" computer? It was not light enough.

Grid-tie inverters are showing a similar "bigger is better" trend, handling 12-36 volts of DC input in the early days to a thousand volts and greater today. This paper suggests that the one-panel/one-inverter approach taken by microinverter manufacturers lends itself better to economies of scale through circuit integration. Millions of panels will require millions of microinverters, making it economic to put the microinverter controller on a single integrated circuit chip, which can then be mass-produced very cheaply. The same microinverter design can be used not only with solar panels but, in the future, with solar *roofing*, placing the solar panel itself within the well-established AC ecosystem.

Sizing Wind Towers and Turbines

It is the wind industry that flaunts its giantist approach. Starting with turbines in the hundred-kilowatt range more than two decades back, progressing to 1-2 MW wind turbines on 50-80 meter hub heights at the turn of the century, wind designers graduated rapidly to 3 up to 5-MW turbines. Monsters with 7 MW and higher capacities are starting to come online [13], and 10-MW and above super-monsters are probably not far behind, on towers exceeding 150 meters.

Wind designers cite very good reasons for this giantism.[7] Higher towers allow for longer blades. Since the power that can be extracted from the wind is proportional to the square of the blade length, this does argue for taller towers that can accommodate longer blades. More important, taller towers enable wind turbines to reach heights where winds are faster, steadier and less turbulent. And since the power that can be extracted from the wind is proportional to the cube of the wind speed, this is an even bigger reason in favor of taller towers.

But that is just one side of the argument. After all, mainframes did have their justifications too.

Let us look at the other side. Higher towers are heavier. So, they must be supported with a larger base. Assuming that the best materials and structural designs possible are already being used, then strength will vary with the cross-sectional area. To double the strength, this area must be doubled. But doubling the area doubles forthwith the weight of the structure. Thus, the extra strength is just enough to carry the additional weight. Because the structure usually tapers with height, some additional height can be attained from the additional area, but not much. In fact, for a given structural material and design, a height limit exists. Beyond it, the risk of structural failure goes up.

The second point is the length of the blades. The tip speeds of very long blades can easily approach the speed of sound, setting an upper bound on wind speeds that big turbines can harvest from. But more massive blades also require higher wind speeds just to start, setting a lower bound on harvestable wind speeds. In short, as turbines get bigger, their operating range tends to get narrower.

In the lingo of Internet design, tower height and wind turbine size *do not scale up very well*. Without doubt, the scaling direction they are taking today will eventually mire the future wind industry in the economics of diminishing returns.

This paper suggests that giant wind turbines are bound to follow a similar trajectory as computer mainframes—they will get larger and larger, but they will eventually be surpassed by their micro-sized counterparts.

Research on making small wind turbines vastly more efficient—so that they can extract energy better from turbulent as well as from laminar flow—are easily justified if the costs can be amortized over millions of units. This paper suggests that the potential of downsizing wind turbines to attain better economies of scale through quantity rather than size offers better promise for the expansion and growth of the industry.

Sizing Hydroelectric Plants

Another good candidate for downsizing is the hydroelectric plant. One can think of extracting hydroelectric power from a stretch of sloping water flow either by extracting power from the full length of the resource in a single mega-project, or by splitting the resource into shorter stretches that can then be developed separately. Again, it is easy to understand the argument in favor of one big project: a single feasibility study, a single financial arrangement, and a single mega-effort to implement the mega-structure [14]. Just like a mainframe.

Given the lessons we have learned from microcomputers, the Internet, mobile phones and solar PV panels, however, it makes sense to check whether the same downsizing trend can also be applied to the hydroelectric sector to create the conditions for a mass market of microhydro facilities, services and components and bring about potential economies of scale.

For instance, by downsizing towards operating pressures that are low enough, a hydro project can shift from stainless steel and other expensive metal penstocks to plastic-based and other lighter and lower-cost penstock materials. [8] This change can result in a significantly lower material costs. And if the penstock material becomes significantly lighter, it can also result in lower labor and installation costs.

2.2. Piggy-back on Existing Products and Standards

Market leaders in the information economy are masters in piggy-backing on existing products. Early microcomputers, for instance, piggy-backed on audio cassettes and later the standard 8-inch floppy disk for storage. Thousands of new products were piggy-backed on the Apple II and IBM PC ecosystems. It is the cascade of new products built on top of earlier ones that built the Internet and the Web of today. The best of them eventually took over these markets.

In the early stages of the renewable economy, many new concepts and products have to be developed, and R&D costs will tend to be very high. By piggy-backing on existing, off-the-shelf items which are already mass-produced, development times can be shortened and development costs lowered.

In the hydro sector, good examples of piggy-backing include the pump-as-turbine approach [4] [5] [21] and the induction-motor-as-generator approach [4] [11] [12] [16] [17]. Many more water pumps are made than turbines; the same is true with induction motors, compared to synchronous generators. By using centrifugal pumps with integral induction motors, it may be possible to trim a huge chunk from the cost of turbine-and-generator R&D and fabrication. Although somewhat lower in efficiency, this off-the-shelf combination can be significantly lower in cost. It will also shorten the project timeline and reduce financing and other time-related costs. If the lower overall costs lead to significant market growth, the market expansion can eventually fund the R&D to bring the system's efficiency back to the usual industry standards.

Another example of piggy-backing is the use of electric posts and off-the-shelf vehicle parts—particularly the differential, axle and wheel hubs—to build wind mills for water pumping [6]. The dramatically lower costs of this approach can create a secondary market for ageing gasoline and diesel-fueled vehicles that are scheduled for phase out, especially as electric vehicles go mainstream. A third example is the proven wind technology for converting “wild alternating current” to direct current and subsequently clean AC. Adapting this technology for run-of-river microhydro facilities, for instance, can help the microhydro industry reduce costs further by bypassing the need for more expensive hydraulic and mechanical controls to maintain frequency and voltage output.

A fourth is to apply maximum power point tracking (MPPT), routinely used in solar panel inverters, to microhydro facilities.

In the Philippines, my organization, the Center for Renewable Electricity Strategies (CREST) is currently experimenting with some of these possibilities to dramatically bring down the cost of micropower.

Adapt Existing Standards

Standards help propel competition, cost reduction, and market growth by enabling the interchangeability of parts, components and even systems. Going back to the pump-as-turbine example, standard off-the-shelf pump sizes can give microhydro developers a good head-start, compared to competitors who insist on designing made-to-order turbine-and-generator combinations that uniquely fit each individual site.

Once a mass market for microhydro emerges and establishes itself, the industry can then design more efficient turbine-generator combinations for this growing market to replace the less efficient centrifugal pump-and-induction motor combinations as soon as they pay for themselves or as they reach the end of their useful life. This time, however, these micropower turbo-generators should be able to show features typical of mass-marketed commodities: standard sizes, a low-cost bare-bones set-up, optional accessories that are interchangeable across different systems, and so on. One can imagine a secondary market of add-ons eventually growing around the basic micropower installation.

The electric vehicle industry is starting to show its own virtuous cycles of increasing production and declining prices. This huge industry will be adopting its own standards particular around battery storage: standard voltages, testing protocols, charging practices, battery sizes, cable connectors, and so on. The EV industry tends to replace batteries when they have lost 20% of their storage capacity, because maximum range is an important selling point for electric vehicles. These discarded batteries can still serve as perfect storage for rooftop solar and other renewables. By unifying their battery standards early in the game, the EV and the renewables industry can both enjoy a vastly larger market for their products, and possibly trigger more economies of scale. The purchase by EV manufacturer Tesla of SolarCity should make it easier for the two industries to adopt common battery standards.

An interesting case in standards is the reprise of the supply-side debate between Edison and Tesla on direct current versus alternating current supply. The debate today is between DC and AC on the demand side. Given the DC output of solar panels as well as wind turbines that convert “wild AC” to DC, the DC requirements of LEDs lamps, laptops, and mobile phones, and the DC nature of battery storage, strong arguments exist in favor of demand-side DC. However, the supply from the grid is AC and most appliances require AC. The development of the AC battery also helps strengthen the argument in favor of AC. An AC battery contains built-in electronics to take care of the AC-to-DC as well as the DC-to-AC conversion. Thus, it can directly charge itself from as well as supply power to the AC line. Putting the required controller into a single chip for mass production will eventually make the cost of conversion relatively insignificant, especially if the chip can be used for both
batteries and solar panels.

Although DC standards for cars and trucks as well as AC standards for household electricity already exist, buyers who are shifting to renewables still face the risk of early obsolescence should they pick the standard that eventually loses out.

But betting on a standard that loses out in the long run is still better than getting stuck with non-standard, one-off components and designs.

2.3. Rely More on Digital Hardware, Integrated Circuits and Software for Flexibility, Lower Cost and Programmability

An important key in the development of the early information economy is digital electronics and the mass production of the 7400 series of low-cost digital integrated circuits. This led to a rapid decline in the cost of building electronic control systems and devices. Culminating in the development of microprocessors and microcontrollers, digital electronics made computing power, memory, and built-in intelligence available at a dramatically lower cost to industrial machines, including micropower plants. As these machines become cheaper and easier to use, these can turn into consumer appliances, expanding their potential market dramatically. It is already possible to imagine solar home systems as appliances that exchange electricity with the grid and making their own decisions to optimize income and savings for their owners. Further down the line, as their costs decline further, solar panels can then be embedded within other consumer items, creating entire new markets and triggering more virtuous cycles.

Another approach that can drive down costs in the renewable economy is to gradually replace hydraulic, fluidic, mechanical and analog electrical control equipment with digital electronics, which will allow the benefits of scale economics that are already in place in the information economy to spill over into the energy sector, especially for markets large enough to justify medium- and large-scale circuit integration.

Digital electronics have a further built-in advantage: they can be designed to be highly flexible and easily programmable. Program changes can be made quickly, distributed easily and even installed remotely. Software reproduction and distribution also entails lower costs, compared to the fabrication of hardware. The advantages of digital electronics can be further enhanced by providing machines with built-in logic and arithmetic processing power as well as memory and storage—already very cheap thanks to developments in the information economy.

Once the market for these control electronics become large enough, circuit integration can put them into a single chip. The ensuing mass production can lead to new rounds of cost reductions and market expansion.

This approach can be done not only on the supply-side, but also on the demand-side. Behind-the-meter equipment can acquire the same built-in low-cost intelligence. This will enable rapid ramping up or down of demand in response to sudden changes in supply that will happen more often as variable sources like solar and wind increase their share in the electricity mix.

2.4. "Killer Apps"

The first commercial killer-application in the microcomputer industry ran on the Apple II microcomputer. It was Visicalc, the very first spreadsheet software. This killer-app transformed the Apple II—and subsequently other microcomputers as well—from a hacker's toy to a business machine that any accounting operation had to have. Visicalc was the first in a long series of killer-apps which helped ensure the continuous growth of the nascent microcomputer industry. The term is less frequently used today, but the concept continues to propel innovations on the Internet. The hypertext mark-up language (HTML) was the server-side killer-app that spawned the World Wide Web. The first graphical browser, Mosaic, was the user-side killer-app which turned the Web into a mass phenomenon. These were quickly followed by search engines, peer-to-peer methods, wikis, blogs, and then social media. The growth of smartphones also relies on new generations of killer-apps.

To propel growth in demand, the renewable economy must think in terms of killer-apps. The low-power solar lamp and cellphone charger is a killer-app in off-grid areas. The first battery-solar panel combination that passes grid parity will be a killer-app where the grid is unreliable and power outages as well as severe voltage fluctuations are common. The solar panel that is designed to be installed as roofing material will be a killer-app. The first affordable roof-mounted wind microturbine that can harvest energy from the slightest whiff of wind and turbulence will probably be a killer-app. For consumers to shift to renewables in droves, applications must meet needs that are so compelling that the consumer must simply have them.

2.5. "Plug-and-play"

Killer-apps open up new markets because users feel compelled to buy them. But less compelling applications may also open up new markets through ease-of-use. Some products involving old, time-tested applications became best-sellers anyway because they were so intuitive and easy to use. A plug-and-play solar PV system will probably open up new markets, just as plug-and-play microturbines for wind and flowing water will.

2.6. Pricing "Sweet Spots"

Producers should be sensitive to what economists call the reservation prices of consumers, the price point at which a significant number will enter the market. These are often called pricing "sweet spots". Priced above the sweet spot, a product may move sluggishly. But priced below the sweet spot, it may enjoy brisk sales. In the U.S., for instance, the sweet spot for newly-introduced entry-level desktop computers stood for a long time around a thousand dollars.

Microhydro systems may exhibit a higher sweet spot for local government projects, and a lower one for farm owners with access to fast-flowing water. Just as solar panels had to drop in price by an order of magnitude or more, before they found those sweet spots that appealed to mass markets, microhydro vendors may need to strive for further price reductions, until the market responds strongly enough to activate economies of scale. Micropower suppliers who are able to pinpoint these sweet spots and manage to reach them through heroic R&D efforts can expect ample rewards from responding consumers in terms of greater market share. Identifying sweet spots will require detailed market studies and long-term test marketing. To start off the discussion, this paper offers these initial suggestions: a microhydro project for a municipality should cost less than a low-cost single-family house. For farms, it should cost less than a cheap car. And for the do-it-yourself crowd, less than the price of a computer. With such prices, one can almost imagine an impulse to buy—if only to try—the new technology.

Imagine microwind turbines that turn at the slightest whiff of air, accumulating their micro-output in microbatteries and powering intelligent microdevices in homes and buildings. In fact, these microturbines do not even have generate electricity. If they can move air, they can find applications in residential and commercial structures. If they cost about as much as a lighting fixture and its bulb, would not consumers be interested?

2.7. Make the Product Multi-functional

The incredible value of today's computers is measured not only by their high benefit-to-cost ratio and the extent of their connectivity but also by the sheer variety of things that they can do. The number of functions that a computer can be used for today is limited only by the number of different applications one can download for it. Likewise, today's smartphone is not just a phone. It is also an audio recorder and player, a camera, and video recorder and player, a browser, an alarm clock as well as timer, and many more. It can measure distance, determine location and count steps like a pedometer. To expand their markets, energy products must provide more functions and meet more needs, while becoming more affordable.

Let us apply the multi-function idea to solar panels: they can become the roof itself, or part of the wall that faces the summer sun. The new round of construction savings can trigger more virtuous cycles. Then, as solar prices drop further, one can imagine new products such as solar tablets and solar wearables like hats, shirts, wrist bands, etc.

With the proper stainless steel or copper tubing in place, a solar array can also be a water heater. As a bonus, the lower operating temperatures will further increase the array's solar conversion efficiency. As a further bonus, the attic will be cooler too.

2.8. Plan for Interconnectivity

The electricity grid, which is in fact an internet of energy sources and sinks, antedates the Internet by more than a hundred years. Electric utilities should therefore be the first to recognize the benefits of interconnectivity. Unfortunately, they are blinded by their fear of distributed generation as a threat to their business model and are fighting hard to delay if not stop its spread. Perhaps, reviewing the history of the Internet can help utilities relearn this basic lesson—that interconnectivity adds value to stand-alone, isolated systems. This network effect is also called demand-side economies of scale. [3]

Things that do a lot in isolation can do much more—and in a much better way too—when they are interconnected. The network effect of positive externalities as more interconnections are added to a network leads to new virtuous cycles of increasing benefits and declining costs. When personal computers got connected to the Internet, new rounds of market expansion and cost reductions occurred. The mobile phone industry recognized from the beginning the value of interconnectivity and embraced it—starting with texting, then bluetooth, and finally wifi. As a result, the Internet today has become a platform for all kinds of new businesses and value-creating activities not only for computer users but also for smartphone users.

The physics of electricity requires supply to equal demand at all times. Any mismatch can cause overheating and eventual damage to either utility equipment or consumer appliances. If the output of a stand-alone PV, wind or hydroelectric plant exceeds demand, it often has to be wasted through a “dump load”. Or it can be stored in batteries, but at a significantly higher cost. If the in-house supply is not enough, the consumer will have to find another source to provide the balance. If the supply and well as demand vary often, unpredictably and in big increments, an isolated stand-alone system will find it next to impossible to balance the two.

Connected to a grid, however, a system can share any excess output with the grid, and cover any shortage by importing power from the grid. When the grid itself has too much supply—or does not have enough—the cost of storage and/or peaking plants can be shared among the many grid users. Consumer-side economies of scale—also called the network effect—takes over.

Thus, renewables must plan for interconnectivity. In the future, households will be exchanging electricity with the grid in a peer-to-peer manner, exporting energy to the grid some of the time and importing from the grid at some other times. New business models and peering arrangements must be developed for this purpose.

If utilities see their future from this perspective, they might perhaps learn to encourage and embrace emerging off-grid, microgrid and mini-grid solutions as potential markets that will want energy connectivity in the future. Who knows what kinds of new businesses and value-creating activities will come out of them and the new energy interconnectivity platforms?

Utilities who can appreciate these developments and prepare for them will have a promising future. Those who cannot will go the way of mainframes and landlines.

The grid will definitely continue to play a major role in energy systems of the future.

2.9. Try Peer-to-peer Business Models Too

The grid has until recently always patterned itself after the highly-centralized, top-down, client-server model of big power plants providing electricity to a mass of consumers. It was probably the grid that inspired the computer industry's business model of dumb terminals connected to large mainframes. This model continues to find expression on the Internet through big mail servers, Web servers, database servers, search engines, etc. that provide highly-centralized services to millions of clients.

However, Internet business models based on more decentralized, bottom-up, peer-to-peer exchanges—also called “co-provision” [15]—have emerged and proven their effectiveness too. These include the free/open source model of software development, the bit-torrent method of file exchanges, crypto-currencies patterned around Bitcoin and its block-chain technology, and others. These have even found expression in hardware development, scientific and academic publishing, and other fields.

As more and more homes and business establishments put solar panels on their rooftops, ushering a wave of distributed generation that can also include microwind, microhydro and other forms of micropower, most will want to keep their grid connection. They will often have excess production, which they might want to sell to the grid or to share with others; or they might need more power than what their existing sources and storage devices can provide. Business models that can keep close track of and fully account for these peer-to-peer exchanges can avoid unnecessary wastage of excess power. In fact, net metering as it was originally developed and practiced in the U.S. provides the best mechanism so far in accounting for these energy exchanges, especially when neighbors become willing to pool their energy surpluses into a commons.

In the future, the quality of the energy exchanged on the grid may lead to price differentiation among different sources—based for instance on their carbon-content or toxicity of by-products—leading to entirely new markets for energy. Electric vehicles, for instance, may want to rent their batteries out as storage and ancillary services when they are garage-bound. These possibilities can turn the grid into a universal platform for sharing or trading energy and power, just like the Internet today has become a universal platform for trading information. It is not far-fetched to imagine accumulating credits for net energy uploads, just as uploaders today earn credits in file-sharing sites. Markets can later arise where these credits can be bought and sold for cash or perhaps using crypto-currencies.

2.10. Let the Government Do the Resource Assessment and the Bulk of the R&D

Aside from their basic role in providing a supportive policy and legal environment, governments can play another positive role in the ongoing shift to renewables by shouldering the responsibility for comprehensive resource assessments of the renewable potential of their country and various sub-national territories. Detailed community-level solar, wind and river atlases must be produced, and low-cost resource maps must be made available to the public, to generate community and household enthusiasm for micropower.

Governments did much of the early research on computer networking and the Internet. The government can also help by conducting the bulk of research and development and absorbing their costs, and then making the results available for exploitation by businesses. This in turn provides a level playing field for all and avoids the growth of monopolies that can stunt these virtuous cycles of declining prices and expanding production.

3. The Economic and Social Consequences of Declining Costs

The declining prices and growing abundance that accompany the virtuous cycle of increasing demand and supply generates a powerful economic force called substitution [18]. As goods and services that decline in price compete with similar but more expensive goods, a steady replacement process occurs. Old expensive ways of doing things are replaced by newer lower-cost ways of doing so. Sooner or later, as the substitution process relentlessly takes effect, the lower-cost product or service becomes the dominant—if not the universal—way of doing things. The mainframe gives way to the small computer. The landline gives way to the mobile phone. The shopping center gives way to the Internet. The expensive and the scarce give way to the lower-cost and the abundant. Similarly, oil and coal will eventually give way to microrenewables.

The new products and services that take over require their own unique procedures and practices as well as new business models. Their consumers will acquire new habits and new ways of thinking and doing. Economic change begets social and cultural change. If the changes are deep enough, a new social system—a new civilization even—emerges.

Thus low-cost, abundant goods carry the potential to become deep game-changers. They can change the rules of the game not only within their own industrial sector, but within society as well.
Although scarce items may be highly-prized in society, it is the affordable and the abundant that become the foundational building blocks of societies and civilizations [10].
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The abundance of wood and other biomass fueled humanity's early use of fire. Subsequently, the abundance of fossil fuels and metals propelled the Industrial Revolution. It is the abundance of silicon, transistors and integrated circuits that launched the information revolution and continues to propel it today. These foundational materials of civilizations are deep game-changers, but their abundance makes it easy to take them for granted. It also makes them less interesting to most economists, who prefer to focus their attention on economizing scarce economic goods which are poor universal material and energy sources for building societies and civilizations precisely due to their scarcity. [19]

If the measures suggested here manage to trigger virtuous cycles of increasing production together with declining costs through economies of scale, then renewables may yet turn into one of the foundational building blocks of 21^{st} century societies.

4. Conclusions

When market sizes and production levels become large enough, producers may reach a point where economies of scale are activated. With economies of scale activated and their costs further reduced, producers are then enabled to respond to the increased demand with higher production instead of getting discouraged by the low prices. Negative feedback turns positive, and a virtuous cycle of increasing production and declining prices is triggered.

This is how the computer industry grew. As computers became cheap enough, they started replacing older and more expensive ways of doing things, causing a new round of virtuous cycles in other sectors of the economy too.

Cascades of activation of economies of scale and virtuous cycles of increasing production and declining prices led to the rapid growth of the Internet, creating new virtuous cycles in many other sectors of the economy.

As the effects of substitution rippled outwards, they were accompanied by further social and cultural upheavals, changing the rules of the game not only in the computer industry and the information economy but the rest of society too.

The emerging renewable energy industry shows promise of going through a similar phenomenon of expanding markets, declining prices and increasing production. In the process, it promises to resolve the triple dilemma of ensuring energy security, energy equity and environmental sustainability.

Learning from the lessons of the information economy, this paper suggests ways by which markets can be expanded and costs reduced in the renewable energy sector. These include: 1) downsizing; 2) piggy-backing on existing products and standards; 3) relying more on digital hardware and on software; 4) developing "killer-apps"; 5) making products "plug-and-play"; 6) identifying pricing "sweet spots"; 7) make products multi-functional; 8) planning for interconnectivity; 9) exploring peer-to-peer business models; and 10) letting governments do the resource assessment and the bulk of the R&D.

Under the right conditions – including the appropriate technologies that make economies of scale possible, the right business models, and a responsive market – things may fall into place. Then, the ensuing virtuous cycles of growing markets and declining prices driven by economies of scale can create a cascade of abundance that causes deep changes in society and improves the lives of millions.

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Chapter 22
Energy efficiency: a new way of providing electricity

It was E.F. Schumacher who said that many technologies contain built-in value-systems, and when a particular technology is adopted, its users will find it hard to avoid absorbing the value-system—ideology, if you will—that is embedded within that technology. A similar idea, "we shape our tools and thereafter our tools shape us", is usually attributed to media theorist Marshall McLuhan. And we might hasten to add: our tools can shape us in ways that we did not anticipate. In short, technologies can also be drivers of social change themselves, for better or for worse.

Let us take the example of solar power on one hand, and wind/hydro power on the hand. Because solar power can be installed on a roof, every household has the potential to use the technology to attain energy independence. Because wind and hydro—and for that matter most big generating plants—attain better efficiencies as they are scaled up, the most efficient will be those operated by big, capital-rich organizations like corporations and governments. It is easy to see that the spread of solar panels on rooftops will lead to very different social consequences compared to the spread of wind and hydro power, even if the latter are both renewable. For instance, those who rely on solar power for most of their electricity will probably start to reorganize their household activities so that the electricity-intensive ones happen during the daytime.

A similar observation can be made between household-scale storage technologies like batteries and fuel cells on one hand and grid-scale storage technologies like pumped hydro, liquid metals or compressed air on the other hand. Household-scale technologies will encourage highly-independent thinking in households, while large-scale technologies will give rise to high-centralized social, economic and political institutions to manage these technologies.

Consumers pay for electricity because they want a particular service, like lighting (so that they can read at night), heating (to cook meals), mechanical power (to run a water pump or an electric fan), or electronic applications (to watch TV or use a computer). The latter are called energy services. Consumers are actually after these energy services, not electricity per se.

One can, for instance, imagine using a gas lamp to light up the evening's dinner, an LPG stove to cook one's meals, or the sun to dry one's clothes. It just so happens that consumers may prefer to use electricity to provide these energy services, because electricity is more convenient.

It is not always necessary to generate more electricity to provide more energy services to the consumer.

It is not always necessary to generate more electricity to make more energy services available to the consumer.

Consumers can also save on electricity that has already been generated, so that these savings may be used to provide additional energy services. In other words, they can improve the productivity of energy, so that the same amount of electricity can provide more energy services.

Energy productivity can be improved in two ways, both of which involve a change in mindset:

1. *Energy conservation.* A consumer can cut down on energy services which are wasteful, and then use the electricity saved for other energy services. By turning off a 50-W incandescent lamp in an empty room, for instance, the consumer saves on an energy service that was unnecessary anyway, and makes available 50 W that can now be used to provide another energy service. A watt saved, to be used elsewhere, is often called a "negawatt" because the watt became available not by being created in a generating plant, but by reducing the consumer's electricity consumption. Note that energy conservation costs very little, if at all, to implement. It is the cheapest way to provide more energy services.

2. *Energy efficiency.* A consumer can provide the same energy service, but use less electricity to provide the service. Replacing the 50-W incandescent bulb with a 12-W LED lamp that provides the same amount of light, for instance, saves 38 W but provides the same service. Now, every time the light is turned on in the room, 38 W are being saved, compared to the old lighting set up. These 38 "negawatts" can then be used to provide other energy services. Energy efficiency usually involves the replacement of a less efficient technology (like the incandescent lamp) with a more efficient one (like the LED lamp), thus it incurs some costs. Nonetheless, the costs are often considerably lower, compared to the investment needed to increase the generation capacity of a grid by 38 W.

Energy productivity is the term often used, to describe these two ways of providing more energy services without adding new generating capacity.

Measures that improve energy productivity are often cheaper than constructing new generating plants to provide the same amount of electricity. Muller, for instance, showed that in a typical American home, reducing energy consumption by investing in improved home insulation in the attic is equivalent to a tax-free, no-risk investment with a 17.8% annual rate of return, while replacing a 75-W incandescent bulb with a 22-W CFL is a tax-free, no risk return on investment of 209% per year.[113] Today, LED lamps would make a much better replacement, due to concerns about mercury pollution from CFL lamps.

113 Muller, pp. 114-119.

Muller estimates that, in general, the average return on investment of energy efficiency programs "is about 2.5 times greater than the return on a new power plant".[114]

The average return on investment of energy efficiency programs is about 2.5 times greater than the return on a new power plant.

The original and still the best advocate for energy efficiency has been physicist Amory Lovins, whose piece "Energy Strategy: The Road Not Taken"[115] carefully worked out the concept of energy efficiency, turning it into a workable, actionable program.

Improving energy productivity through demand-side measures such as these will perfectly complement parallel supply-side measures to speed up the shift from fossil-fuels to renewables.

The role of technologies in changing our energy base is also illustrated by authors McDonough and Braungart who wrote that "[technological] design is a signal of intention." They look at the entire history of industrial revolution and development as a parade of (mostly bad) designs.

McDonough and Braungart's book *Cradle to Cradle: Remaking the Way We Make Things* includes stories about their (and others') efforts to redesign technologies based on a different perspective.[116] It describes how the authors embedded a different value-system or ideology, so to speak, in their designs, with spectacularly positive consequences in various areas, including energy consumption.

McDonough and Braungart were not content with the "less bad". "What about a different model?" they ask. "What would it mean to be 100% good?" This is a deep change in mindset.

It meant the redesign of existing technologies or creation of new ones by embedding a different set of design intentions within their products, particularly the intention not just to be "less bad," but to be "100% good." The McDonough-Braungart approach is decidedly a combination of social intention and technological implementation.

Consider for instance how the two, who were also business partners, designed in the early 1990s a compostable upholstery fabric for mass production. The design was not focused on energy, but is nevertheless a perfect illustration of their approach. Their first try used natural cotton and recycled PET bottles. Since upholstery gets abraded during normal use, they had to make sure that minute particles from the material, if swallowed or inhaled, will not be harmful. PET did not fit the bill. Combining the two materials into a hybrid also meant that the worn fabric could neither be composted nor easily recycled. Instead of settling with this "less bad" material, they worked on something else that was "100% good," they "decided to design a fabric that would be safe enough to eat: it would not harm people who breathed it in, and it would not harm natural systems after its disposal. In fact, as a biological nutrient, it would nourish nature."

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114 Muller, p. 120.

115 Amory Lovins, "Energy Strategies: The Road Not Taken," *Foreign Affairs*, October 1976.

116 William McDonough and Michael Braungart, *Cradle to Cradle: Remaking the Way We Make Things,* (New York: North Point Press, 2002).

We will now let McDonough and Braungart continue to tell their story:

> "The team decided on a mixture of safe, pesticide-free plant and animal fibers for the fabric: wool, provides insulation in winter and summer, and ramie, which wicks moisture away. Together these fibers would make for a strong and comfortable fabric. Then we began working on the most difficult aspect of the design: the finishes, dyes, and other process chemicals. Instead of filtering out mutagens, carcinogens, endocrine disrupters, persistent toxins, and bioaccumulative substances at the end of the process, we would filter them out at the beginning. In fact, we would go beyond designing a fabric that would do no harm: we would design one that was nutritious.
>
> ". . . We ended up selecting only thirty-eight [chemicals], from which we created the entire fabric line. What might seem like an expensive and laborious research process turned out to solve multiple problems and to contribute to a higher-quality product that was ultimately more economical.
>
> "The fabric went into production. The factory director later told us that when regulators came on their rounds and tested the effluent (the water coming out of the factory), they thought their instruments were broken. They could not identify any pollutants, not even elements they knew were in the water when it came into the factory. . . . The equipment was fine; it was simply that by most parameters the water coming out of the factory was as clean as—or even cleaner than—the water going in. When the factory's effluent is cleaner than its influent, it might well prefer to use its effluent as influent. Being designed into the manufacturing process, this dividend is free and requires no enforcement to continue or to exploit. Not only did our new design process bypass the traditional responses to environmental problems (reduce, reuse, recycle), it also eliminated the need for regulation, something that any businessperson will appreciate as extremely valuable.
>
> "The process had additional positive side effects. Employees began to use, for recreation and additional work space, rooms that were previously reserved for hazardous-chemical storage. Regulatory paperwork was eliminated. Workers stopped wearing the gloves and masks that had given them a thin veil of protection against workplace toxins. The mill's products became so successful that it faced a new problem: financial success, just the kind of problem businesses want to have.
>
> "As a biological nutrient, the fabric embodied the kind of fecundity we find in nature's work. After customers finished using it, they could simply tear the fabric off the chair frame and throw it onto the soil or compost heap without feeling bad—even, perhaps, with a kind of relish. Throwing something away can be fun, let's admit it; and giving a guilt-free gift to the natural world is an incomparable pleasure."[117]

In energy systems, McDonough and Braungart promote the energy-efficiency concepts originated by Lovins in the design of homes and buildings. But they eschew the term "efficiency" and prefer to call their approach "eco-effectiveness." They cite various examples of traditional architecture that had solved the problem of keeping homes comfortable despite extremes in outside temperature. To them, "connecting to natural energy flows is a matter of reestablishing our fundamental connection to the source of all good growth on the planet: the sun, that tremendous nuclear power plant 93 million miles away." From this perspective, they say, "the greatest innovations in energy supply are being made by small-scale plants at

117 Ibid., pp. 107-109.

the local level. For example, in our work with one utility in Indiana, it appears that producing power at the scale of one small plant for every three city blocks is dramatically more effective than more centralized production. The shorter distances reduce the power lost in high-voltage transmission to insignificant levels."

They tell another story about how they designed a building:

> "Working with a team assembled by Professor David Orr of Oberlin College, we conceived the idea for a building and its site modeled on the way a tree works. We imagined ways that it could purify the air, create shade and habitat, enrich soil, and change with the seasons, eventually accruing more energy than it needs to operate. Features include solar panels on the roof; a grove of trees on the building's north side for wind protection and diversity; an interior designed to change and adapt to people's aesthetic and functional preferences with raised floors and leased carpeting' a pond that stores water for irrigation; a living machine inside and beside the building that uses a pond full of specially selected organisms and plants to clean the effluent; classrooms and large public rooms that face west and south to take advantage of solar gain; special windowpanes that control the amount of UV light entering the building; a restored forest on the east side of the building; and an approach to landscaping and grounds maintenance that obviates the need for pesticides or irrigation. These features are in the process of being optimized—in its first summer, the building began to generate more energy capital than it used—a small but hopeful start. Imagine a building like a tree, a city like a forest."[118]

Theirs is renewable design, not just of energy sources but the total context in which energy is used. As they said, not just "less bad" but "100% good."

In summary, this chapter emphasizes that we should not only look at the production of electricity, but also at reducing our over-reliance on this form of energy. We can imagine the act of saving as an act of production too, because any kilowatt-hour saved is now available for other uses.

In the Philippines, an energy efficiency program can include the following:

1. An aggressive program to promote LED lighting and phase out incandescent and fluorescent lamps. This will help reduce nighttime demand

2. A similar aggressive program to promote rooftop solar, which will reduce daytime demand. This will make a perfect complement to the LED program, reducing overall demand on the grid.

3. One way to kick off this program is to emulate the successful property-assessment clean energy (PACE) programs in the U.S., in which local governments lend to homeowners so that they can install solar panels on their rooftop. The loan payments are attached to real property payments which the homeowner must make annually. This makes these loans very low-risk.

4. Rooftop solar ownership can be further encourage through the full implementation of the net metering provisions of the country's Renewable Energy Act.

118 Ibid., 138-139.

5. Promoting a shift to highly-efficient variable-frequency motors for air-conditioning and refrigeration (popularly known as inverter aircons and refs), can further reduce daytime demand.

6. A program that uses off-the-shelf and even junk motorcycle components can also be launched, encourage the building of mechanical windmills for rural irrigation. This will also help reduce demand on the grid.

7. Finally, an energy efficiency and conservation ritual can be initiated by the government every summer, by encouraging everyone to switch off unnecessary loads when the high summer demand threatens to exceed supply. This campaign needs a combination of *bayanihan* and instant feedback through traditional and social media so that consumers immediately see on TV, computer, or smartphone screens the impact of their action in reducing demand. This is explained in more detail in the next chapter.

Very effective ways of saving energy can be found if we go beyond the sector of electricity—or even the field of technology—into our social practices and lifestyles, and into the way we structure our communities, our relationships and our lives.

If we manage to do this, we will find that renewables are more than enough to cover all our electricity needs. But if we remain stuck in our current social structures, there will never be enough electricity—renewable and non-renewable—to meet our insatiable wants.

Chapter 23
Dealing with the recurring summer shortfall

Every year, there is a lot of talk about an electricity supply shortfall that will hit the Philippines in summer. In 2015, for instance, a 500-MW shortfall in supply was predicted. It was again an issue in 2016, although less so because the Philippines had more rains.

The proposed solutions to this recurring crisis range from fielding barge-mounted, oil-fueled power plants that can be put online quickly, to building more coal plants over the medium-term, and even returning to the nuclear option over the long-term.

In fact, the actual expected shortage in 2015 was only 31 MW, over two weeks in April, according to a testimony of DOE Assistant Director Irma Exconde before Congress in October 2014. Exconde clarified that they had announced a much larger shortage because the DOE also wanted to maintain the ideal reserve of 647 MW, as backup for the largest power generating unit in Luzon. The DOE's proposed solution was "negotiated contracts for rental or for purchase of generator sets for additional power supply for the summer months, which would cost the government an estimated amount of ₱6 billion to ₱10 billion." [119]

Let us adopt an ambitious goal: all new demand should be met through renewable energy.

Using Table 19 in Chapter 3, we can calculate how much solar PV capacity can ₱10 billion buy: 90.9 MWp, available when the sun is up in the summer sky, precisely during the hours when power for air conditioning is needed most. Furthermore, the ₱10 billion will not only cover the expected two-week shortage in April 2015, but will also be supplying afterwards 10 million kWh per month of electricity for the next 20 years!

119 Lira Dalangin-Fernandez, "DOE: 2015 power crisis an issue of reserves, not supply; negotiated deals for gensets junked," October 20, 2014, http://www.interaksyon.com/article/97611/doe-2015-power-crisis-an-issue-of-reserves- not-supply-negotiated-deals-for-gensets-junked.

To minimize the financial burden on the government, the 10 billion could have been released in the form of low-interest emergency loans. If the loans were payable in ten years or more, the monthly savings generated by the PV systems would have been more than enough for paying back the loans.

Given these and the points raised in the rest of this study, it is clear that the 2015 shortfall could have been met by renewables alone.

This is the approach that we recommend to the government.

We strongly recommend that the government adopt decisive measures in 2015 to jumpstart its renewable energy program through a specific and ambitious goal: *henceforth, all new demand should be met through renewable energy*. Let all existing fossil-fueled plants operate in the meantime, but *all future expansion should be based on renewable sources*. We have shown elsewhere (see Chapter 4) that this was a feasible option throughout the Aquino administration's term. More so under President Duterte, with solar and wind costs coming down even further.

After all, the critical period is expected to materialize only at the onset of summer, when the need for daytime air conditioning will stress the ability of existing plants to meet the demand. But the highest insolation also occurs during summer days, in right synchrony with the higher demand. Solar power is clearly the most appropriate solution for the increased summer demand. If the government has to subsidize anything, let it be a renewable solution, not a fossil fuel-based solution.

Former Energy Secretary Petilla had already acknowledged that it is cheaper for consumers to generate their own electricity with solar panels, than to buy coal-based electricity from the grid. In this regard, wind-based electricity is not far behind. This is further confirmed by the rush of solar and wind projects that applied for FIT support, forcing the DOE to adjust their solar thresholds ten-fold.

And solar was, in the past, considered the most expensive of the renewables, while coal was considered the cheapest. The cost/pricing situation has changed dramatically in the past few years.

Opening the floodgates to solar rooftops will not raise electricity prices but will bring it down, because solar panels work best at noon, replacing expensive electricity from “peaking” plants.

Clearly, the issue of cost is already settled. More so in the future, as solar and wind electricity continue to get cheaper, while non-renewables continue to get more expensive. It will be foolhardy to lock-in ourselves today to technology options which are dirty or unsafe—or both—and which will cost us even more in the future, not only in monetary terms but also in their health, environmental and social impacts.

In the past, the solar option was saddled by a financing problem. Since most of solar costs were incurred at the investment, pre-operational stage, early adopters were forced to pay five to seven years' worth of future consumption, in effect, in order to realize savings after the upfront costs have been paid back. No bank was willing to underwrite these upfront costs for households and small businesses, which were generally considered poor risks. Also, consumers were not inclined either to go into debt for those many number of years to save on their electricity bill.

But the entry of Solar Philippines and its business model has changed all this. Under this model, the solar PV system supplier, who knows the technology best, assumes the risks. Consumers then realize savings, starting on the first day of operation, and banks are more willing to lend to a business with PPAs.

In short, the financing barrier is now being solved too. The only problem is that Solar Philippines may not be able to grow fast enough to meet the demand unleashed by its business model. Leviste's company is also biased against residential customers, who are still asked to pay for the full upfront costs of PV systems. Thus, more companies have to get into the act, including ones that focus on low-income residential customers. More banks too.

The government simply needs to do everything it can to encourage more business models of this kind, perhaps by assuming part of the risks itself. The entry of a government agency into solar lending, such as extending loans of up to ₱130,000 for the purchase of a solar PV system when a Pag-IBIG member constructs a new house, is a big step. It will even be better if similar loans were extended to members who also want to retrofit their existing house with solar panels. Other government agencies like SSS, GSIS and the Landbank should also get into the act.

The government should definitely not use the power crisis every summer to justify new construction of coal plants. By the time these plants are ready to go online, the price of their output would have escalated, while the cost of renewables would have gone down even further. And we will be caught in the worst situation of all: locked into a non-renewable and highly-pollutive technology whose fuel we must import and whose output gets more expensive year after year.

If we succeed in 2017 in meeting new demand with renewables—and only renewables—subsequent years will be easier because renewables get cheaper year after year.

The biggest missing piece, after financing, is net metering.

Opening the floodgates to solar rooftops will not raise the price of electricity but will bring it down. This is because the solar panels work best at noon, when the demand is also high and the supply must be supplemented with peaking plants which charge a premium for their services. Since the cost of solar electricity is lower than peak prices, switching to solar will bring down the average cost of generating electricity. This should result in lower electricity rates, as long as the savings are passed on to consumers.

In the Philippines, the greatest motivator today for the adoption of RE is the high cost of electricity. If the government removes all barriers to the entry of households, small businesses and other small players in the RE industry, we can expect consumers to adopt the cheaper RE alternatives in droves.

President Rodrigo Duterte has said that the country needs enough power for its industrialization program. The best thing that the President can do in this regard is to remove the barriers to the participation of ordinary citizens in the country's renewable energy program.

If a single company like Solar Philippines can install 50 MW within a year, there is no reason why a crash RE program initiated under the President's emergency powers cannot do ten times that amount, if it goes all out to prevent the recurring power crisis every summer.

Indeed, the summer shortfall is a timely opportunity to fast-track the government's renewable energy development program.

There is another approach in dealing with such supply shortfalls, that involve the combination of collective action—what we Filipinos call *bayanihan*—and standard technology.

This will be the topic of the next chapter.

Chapter 24
Urgent recommendations

Recommendations can be found in almost every chapter. For emphasis, only three recommendations that urgently demand attention will be reiterated here. These three priorities all address the current exclusion of households and small businesses—the small players—in the energy transition to renewables.

The big players can take care of themselves. In fact, they do enjoy a lot of government hand-holding and support. They are already picking the low-hanging fruits of the renewable revolution. The small players are mostly fenced out, watching the action that is going on.

To participate in the energy transition, the small players need the government to do the following:

1. Require the replacement of all currently installed uni-directional electric meters with bi-directional meters. The original analog meters were already bi-directional and would have served satisfactorily the new accounting requirements of the energy transition. Uni-directional meters enable utilities to perpetrate a scam against solar owners who export their surplus. The solar owners are scammed because they are being charged by the utilities for exporting their surplus, when the law says they should actually be credited for it. Uni-directional meters are like electrified wire that fence off small players into solar hamlets, severely punishing solar owners whose surplus occasionally stray into the grid. Victims of this scam include all those who install a grid-tie inverter without getting a bi-directional meter installed first.

2. Disallow the "distribution impact study" (DIS) fees which are being charged against solar owners who connect to the grid. This is another scam. Imagine a low-income household that manages to borrow around ₱30,000 to buy a 250-Wp solar panel and grid-tie inverter, anticipating savings from their little investment. Because they want to avoid the first scam perpetrated with uni-directional meters, they apply for a replacement meter. But replacing the meter involves an entire package called "net-metering". And part of this package is the DIS payment (at least nine thousand pesos in

Metro Manila), purportedly for the utility to study the impact of the 250-W panel/inverter on their distribution system. For context, remember that a desktop computer may consume 300 W, a 1-HP aircon 750 W, and a microwave oven 1,500 W. If another household with a 250-W solar panel applies for the net-metering package, that household is also charged the same nine thousand-peso DIS fee, so that the utility can again "study the impact of the 250-W panel/inverter on their distribution system". And so on, every new household that wants to install a solar panel on its rooftop getting charged the DIS fee.

3. Implement strictly the net-metering provision in the Renewable Energy Act, which rewards small RE facilities (below 100 kW capacity) with the privilege of offsetting their grid consumption with their renewable energy surplus. The provision and its subsequent elaboration in its Implementing Rules and Regulations and the net metering guidelines of the ERC are very clear about this energy offsetting mechanism, which automatically means a common reference price for both imported and exported energy. But this provision is routinely violated by utilities today, who charge their customers the full retail price, but credit their surplus-exporting customers around half of the retail price only. This issue is explained in detail in Chapters 9 to12.

These three recommendations address the worst barriers to the participation of small players in the ongoing renewable energy revolution.

If implemented, the market can then operate normally, incentivizing those who take advantage of the lower and continually declining costs of solar facilities.

Chapter 25
Should you try solar now?

This study has focused on solar energy because PV systems can be bought off-the-shelf and are simpler to install and maintain compared to wind or small hydro. The continuing drop in the prices of solar panels and associated equipment has convinced us that it is now time for everyone to seriously consider trying this technology—at the level they can afford.

Of course, just like cellphones, computers and similar silicon-based products, dropping prices mean that the longer you wait, the cheaper these things will be. However, waiting also means that you are in the meantime foregoing the benefits of using the technology and learning more about it. So, you will simply have to decide at a certain point that you have done enough waiting, and that it is now time to try.

But before you do, make sure you have kept a detailed record of your electricity consumption, so that you can compare your bill before and after installing your solar panels. It is best if you have data of your consumption and electric bill for at least the previous 12 months.

We suggest that your first try be an exploratory one. Do not try to become grid-independent overnight by producing yourself your entire consumption right away. Also, avoid at the start the additional complication and cost of a battery. Add this option later, after you have mastered the basics of replacing watts from the electric utility with watts from the sun and are confident about the various costs.

We suggest that you start small, **say 50 to 500 Wp.**

Assuming that yours is within the range of a typical household, we suggest that you start small, say 50 to 500 Wp, depending on your budget. Try to size your system so that it will register enough savings for you to see a noticeable drop in your electric bill, say a 25–35% drop.

Let us say that your current consumption is 200 kWh per month. If you target 30% savings, this means you want to produce around 60 kWh per month. Using Table 19 in Chapter 3 to convert kWh per month to kWp, you will arrive at 60 ÷ 115 = 0.52. This means you need a PV capacity of 0.52 kWp or 520 Wp. You can use two 250-Wp panels, which will produce around 57.5 kWh per month (0.5 × 115), a saving of 29%.

Once you have determined from your own experience the true costs and benefits of solar electricity, you can then expand your set-up as you see fit and as your pocketbook will allow. Getting your feet wet and testing the water first also postpones your full commitment, giving the prices more time to drop further.

For your decision-making process, you can use as payback period the number of periods it will take to pay the investment cost of the system, using the amount saved for amortization and adjusting for the escalation of the grid price.

Note that the payback period is *not* sensitive to either the capacity of the PV system or its life time—*as long as the system lasts longer than the payback period*. This means that a 50-Wp system will have the same payback period as a 500-Wp or a 5-kWp system. This also means that systems whose panels last for only 15 years will have the same payback period as systems with 20-year or 30-year panels. Of course, the longer the panels last, the better your return on investment.

Five variables determine payback period

The payback period depends on five variables.

Variables with a direct effect on the payback period:
- the price per kWp of the solar PV system (the higher the price, the longer the payback period)
- the bank lending rate (the higher the rate, the longer the payback period)
- the percentage of savings spent for maintenance, repair, and other expenses (the bigger
- the percentage that go to miscellaneous expenses, the longer the payback period)

Variables with an inverse effect the payback period:
- the peak-hours per day (the more the hours, the shorter the payback period)
- the retail price of electricity and its rate of escalation (the higher the price as well as its
- escalation rate, the shorter the payback period)

Below are some assumptions you can use. We will give figures for a 100-Wp system.

Table 37. Solar Calculations for a 100-Wp PV System

Row	Description	Assumed	Calculated	Unit
A	System capacity	100		watts-peak
B	Current installed cost of PV systems	100		pesos/Wp
C	Total cost of system, A x B		10,000	pesos
D	Peak-hours	4.5		hours/day

E	Gross output. A x D x 30days / month / 1000		13.5	kWh/month
F	System efficiency	0.85		%
G	Net output, E x F		11.48	kWh/month
H	Retail price of electricity	11.5		pesos/kWh
J	Lending rate	9.0%		% year
K	Average escalation in the retail price	5.0%		% year
L	Adjusted interest rate per month, ((1+J)/(1+K) - 1)/12		0.32%	% month
M	Electric bill savings/month, G x H		131.96	pesos
N	Maintenance, repair and misc. expenses	0.15		% of savings
P	Amortization expense, M x (1-N)		112.17	pesos/month
Q	Payback period, NPER(L, P, C)		105.0	months
R	Payback period, Q / 12		8.7	years

Source: Author's calculations.

Let us go through the variables that influence the payback period.

PV system cost

Solar panels, the component that actually converts sunlight to direct current electricity, currently (2014) cost from ₱45.00 to ₱65.00 per Wp. Suppliers charge higher for what they claim are better quality panels (for example, if they are made in Germany or Japan instead of China, or if they are "class A" Chinese-made panels). However, it is hard at this time to evaluate the various quality claims. An independent body that can conduct such an impartial evaluation would be extremely helpful to consumers today.

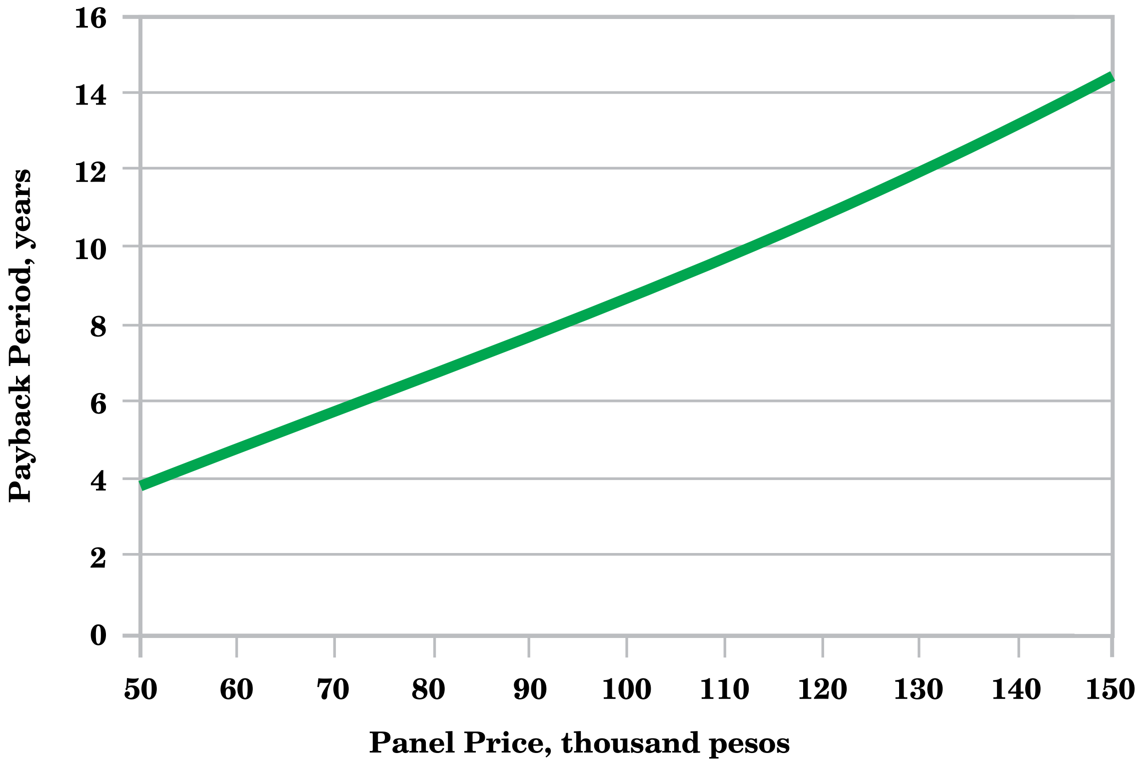
Solar panels currently (2014) sell for P45 to P65 per watt-peak.

A solar PV system includes, in addition to the solar panels, an inverter, and an optional battery accompanied by a charge controller. The general rule today is that a complete system (minus the battery) costs around twice the cost of the solar panels. Applying this rule to the range above gives a system cost range of ₱90.00–₱130.00 per Wp. A properly-sized battery and charge controller costs about as much as the panels themselves. So if you want this option, figure on a system cost that is at least three times the cost of the solar panels alone. Considering that batteries have a much shorter life than solar panels, we would suggest, for your first trial, to avoid the additional costs and complications of a battery and a charge controller.

Complete solar PV systems cost from P90 to P130 per watt-peak.

As the solar PV market expands rapidly, consumers would need to be protected from deceptive advertising and false claims of unscrupulous suppliers concerning the specifications and capabilities of solar panels and controllers that can spoil the benefits of switching to solar energy. The government should ensure the protection of consumers through standards setting, rigorous testing and regular market monitoring.

Figure 13. Sensitivity of Payback Period to Panel Price



Source: Author's calculations.

Mike de Guzman of Makati (see Chapter 6) spent ₱500,000.00 for a 5 kWp system or ₱100.00 per Wp.[120] According to de Guzman's calculations, a 250-Wp solar panel saves ₱200–₱500 per month. Thus, each watt-peak saves ₱0.80 to ₱2.00 worth of electricity consumption per month. Our estimate is ₱1.32 per month per Wp, which is within the range given by de Guzman. Since the solar PV system cost him ₱100.00 per Wp, his ₱100.00 per Wp investment is earning ₱1.32 (1.32%) per month or 15.8% per year, which should be an attractive ROI to many.

The analysis of the sensitivity of the payback period to changes in PV system prices shows a direct linear relationship. With PV prices continuing to go down, this factor is the major driver for reduced prices of solar electricity in the future.

Lending rates

The payback period is quite sensitive to lending rates, which are often the basis of the discount rates used in evaluating the feasibility of investments. The growth in the solar PV market today is benefitting immensely from the lower interest rates currently prevailing in the country.

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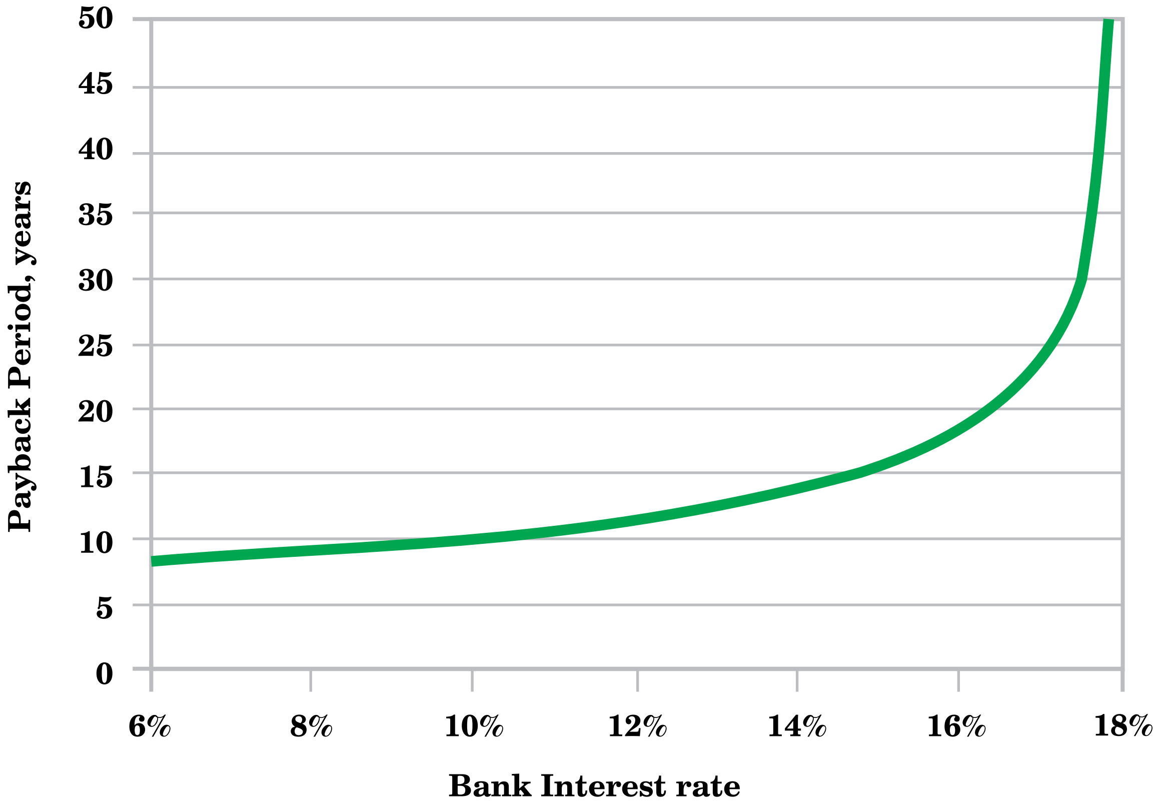
120 http://www.rappler.com/business/industries/173-power-and-energy/64165-solar-power-ph-households-net-metering.

The payback period is sensitive to a big increase in bank interest rates. If the current 9% per annum rate doubles, for instance, then the viability of solar PV projects will be threatened. However, for small changes in the interest rate, the change in the payback period is relatively linear.

Figure 14. Sensitivity of Payback Period to Interest Rates



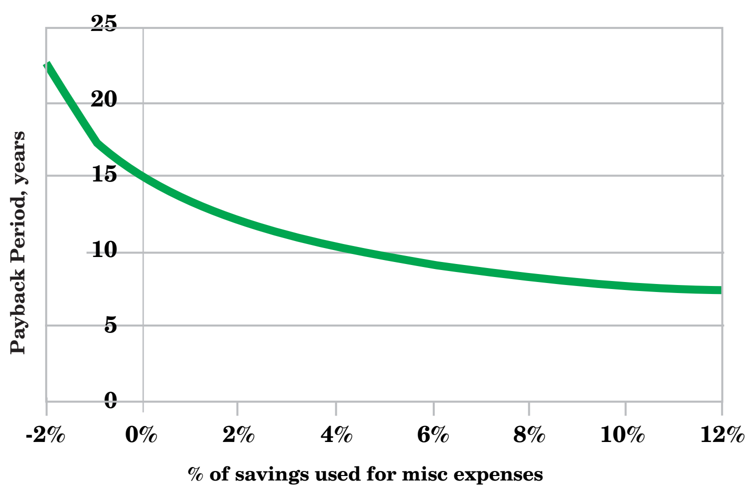
Source: Author's calculations.

The current (2014) lending rate among banks today hovers around 9% per annum. It is hard to determine how long the rate will stay at this level. Unless you have a strong reason to expect otherwise, you can just assume the same rate for the duration of the payback period.

Escalation rates of electricity prices

Historically, Meralco rates have been increasing at around 5% per year. This escalation of electricity retail prices works in favor of solar power users, because their peso savings—and consequently the amount they can spend on loan amortizations—increase in proportion to the price escalation. The effect is equivalent to a reduction in the bank interest rate, as explained in detail in Appendix B.

Figure 15. Sensitivity of Payback Period to Electricity Price Escalation Rate



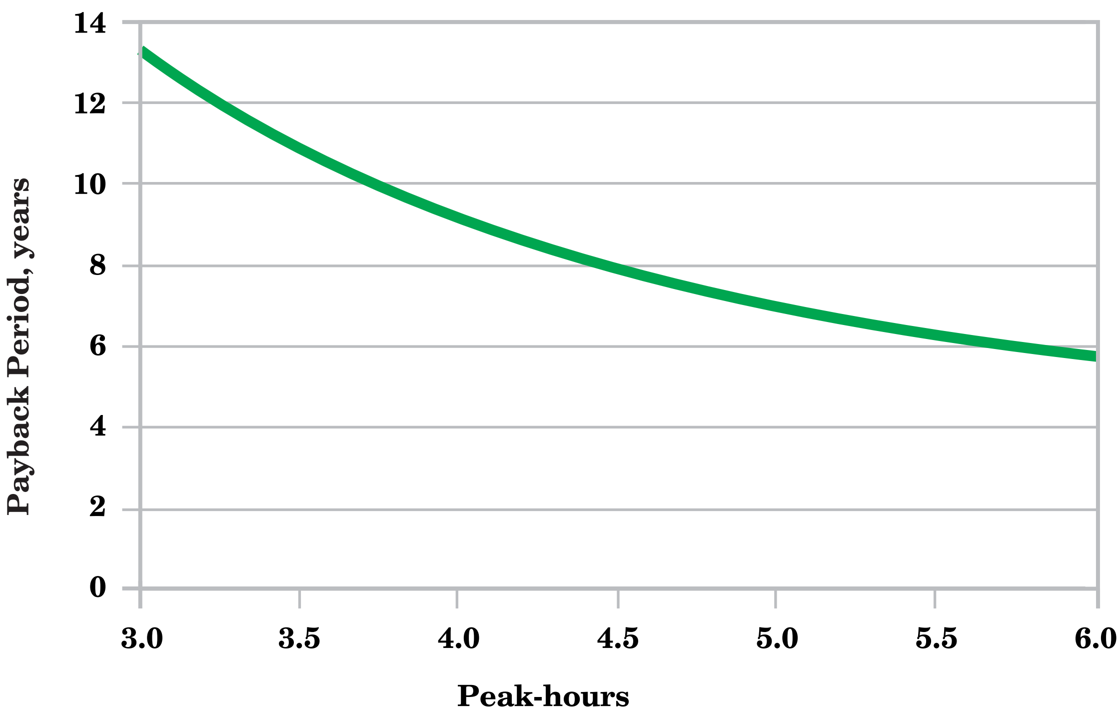
Source: Author's calculations.

Peak-hours per day

In the Philippines, a day may consist of between 3.5 to 5.5 peak-hours, depending on the location. In most of our calculations, we use 4.5 peak-hours per day. If you want to be conservative, you can assume 4.0 peak-hours per day. However, it is best to check the insolation maps for your particular location. It is best to make some measurements at least during the most cloudy as well as the least cloudy months of the year.

Under the 4.5 peak-hours assumption, a one-kWp solar array will produce, on the average, 4.5 kWh of electricity per day, 135 kWh per month and 1,620 kWh per year. The insolation rates in Visayas and Mindanao tend to be generally higher. But in solar, as in wind, everything is location-specific. Site measurements must be taken over at least a year, preferably more. The theoretical models of NREL, applied specifically to Philippine conditions, suggest an insolation range of 4.5–5.5 peak-hours per day. However, these NREL models do not take local pollution into account. Also, these figures refer to the PV panel output. The usable output will be somewhat less, depending on the efficiency of the inverter and the rest of the system. Our calculations assume 85%, which is quite conservative. You can use the solar conversion table in Chapter 3.

Figure 16. Sensitivity of Payback Period to Daily Isolation



Source: Author's calculations

The payback period is quite sensitive to this assumption. It is longer when one assumes low peak-hours, and shorter when one assumes high peak-hours. When a supplier promises short payback periods, check his assumed peak-hours per day.

If you are thinking of investing in a solar PV system yourself, the uncertainty might be a little unnerving. Assuming an average of 3 peak-hours, with 15% of the savings going to miscellaneous expenses and only 85% going to paying the investment back, this means a payback period of 13 years. An average of 6.0 peak-hours means a payback period of seven years. Based on the assumptions we used above, it is 9.8 years. So is it seven years or 9.8 years?

The uncertainty lies in the peak-hours assumption that figures prominently in the calculations, which is inherently uncertain. Daily, weekly and monthly variations in cloud cover make it hard to fix the figure. Of course, highs and lows even themselves out eventually and past experience allows us to bracket the average peak-hours per day, over a month or a year. Multiply the average daily peak-hours by 30 days and by the system efficiency of the PV system (we assumed 85%) to get the estimated average usable production of electricity in kWh per month.

The retail price of electricity

Under the Meralco franchise, today's (2014) retail price hovers around ₱11.50. Meralco's historical records show an average steady increase in their retail prices of 5% per year, which is about 0.41% per month.

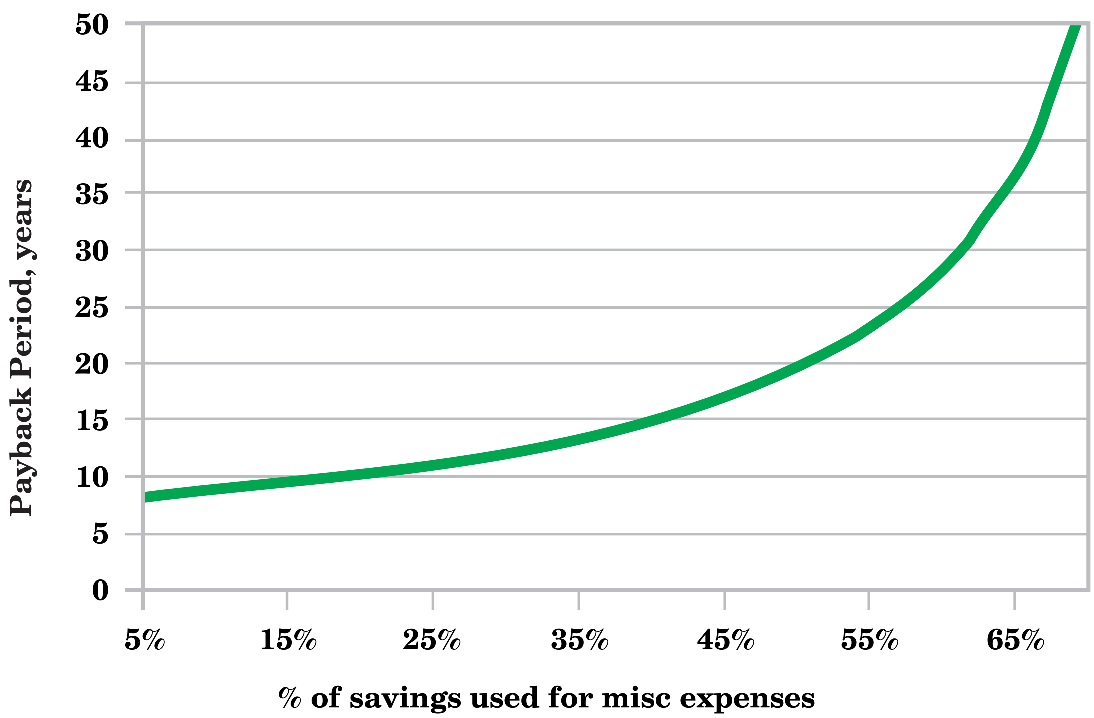
In areas served by other electric utilities or electric cooperatives, retail electricity prices may be higher, or lower.

The higher the retail price of electricity, the more viable renewable sources become.

And if renewables are already within the range of viability today, then they will become more so as electricity prices from non-renewables continue to rise. Thus as the rate of escalation of electricity prices get higher, the shorter will the payback period become.

With these two unmistakable trends, the rising retail price of electricity distributed by utilities and the dropping costs of solar panels, the decision to shift is really a no-brainer. The only question left is whether you should do it today, next year or the year after next.

Figure 17. Sensitivity of Payback Period to the % of Savings Set Aside for Expenses



Source: Author's calculations

And if the banks wake up, and see the savings becoming large enough, they will want a share in the pie. With commercial bank financing opening up, especially if the government takes even more effective steps to minimize the financial risks, we can make the 100% transition to renewables faster than anyone thought possible.

Maintenance, repair and miscellaneous expenses

Among the renewables, solar PV requires the least in terms of maintenance and operating expenses. Still, you must set aside a portion of your savings for this purpose. The rest can go to the amortization payments for the system.

As the sensitivity analysis below shows, setting aside 40% of your savings for miscellaneous expenses and using only 60% for the amortization payments roughly doubles the payback period.

Remember: when suppliers claim a particular payback period, always ask about their assumptions.

The decision to shift to solar is a no-brainer. The only question left is whether you should do it today, next year or the year after next.

For the ordinary consumer, the most interesting finding of this study is that the payback period for such a project is the same, regardless of the capacity, and that the payback periods are now within attractive range. The estimated payback periods of 5–10 years are already acceptable to many people.

Thus consumers can start with whatever capacity they can afford, and expand their system as solar costs drop further. Everyone can recover their investment. Given the proper financing, individual consumers today can make a dent, in the aggregate, on the country's energy mix in favor of renewables.

A small loan pays for a small system which generates small savings for paying back the small loan. A large loan pays for a large system which generates large savings for paying back the large loan.

In both cases, as long as the other system variables do not change, the payback period is *the same*.

This means that consumers who want to install a solar PV system can start with whatever size they can afford, without affecting the payback period.

By using the payback period, we only need to be concerned that the system's lifetime should exceed the payback period. Once the project has paid itself back, all earnings beyond that period are returns on investment.

An energy project may also be evaluated using the levelized cost of electricity (LCOE) approach. This method involves summing up the present values of the various costs of the project and dividing this by the energy production (in kWh) over the lifetime of the project. This approach introduces an additional uncertainty in the results, because one needs a reliable estimate of the lifetime of a solar PV system. But it is necessary to take this approach if we want to validly compare solar PV costs with the costs of other technologies which have also been evaluated using LCOE.

Levelized cost of electricity (LCOE)

Although we have focused on the payback period, it is also possible to calculate the actual cost of solar electricity per kilowatt-hour. The most common method is called the levelized cost of electricity (LCOE). This method adds up the present values of all investment and maintenance/operating costs, and divides this by the total lifetime production of the system. This makes LCOE inversely proportional to the expected lifetime of the PV panels and associated equipment.

Let us go through the exercise, using the 5-kWp panel as example. Let us assume 4.5 peak-hours average daily insolation, ₱55.00 per Wp for solar panels with miscellaneous hardware, with a 20-year life, and the same ₱55.00 per Wp for the grid-tie inverter with miscellaneous wires and connectors, but with a 6.7-year life (i.e., you need to buy three inverters over the lifetime of the solar panels). Assume further maintenance and operating costs of 25% of the solar panel costs. The total lifetime costs will then be ₱1,169,576.00[121]The total output over the lifetime of the system is 139,612.5 kWh[122]

Dividing total cost by total output, we get an LCOE of ₱8.38 (see the following table, under 4.5 peak-hours per day, panel cost of ₱55,000 and panel life of 20 years). If we try other assumptions in daily insolation, panel cost and panel lifetime, we can look up the LCOE in Table 38.

By comparing the LCOE in the table below with the retail price of electricity in your area (see Chapter 1), you can determine whether or not it is time for you to start generating solar electricity on your rooftop.

Table 38. Levelized Cost of Solar Rooftop Electricity (Pesos per kWh)

4.0 peak-hrs/day	Panel cost, P/kWp								
Panel life, years	60,000	55,000	50,000	45,000	40,000	35,000	30,000	25,000	20,000
6	34.27	31.41	28.56	25.70	22.85	19.99	17.14	14.28	11.42
8	25.70	23.56	21.42	19.28	17.14	14.99	12.85	10.71	8.57
10	20.56	18.85	17.14	15.42	13.71	11.99	10.28	8.57	6.85
12	17.14	15.71	14.28	12.85	11.42	10.00	8.57	7.14	5.71
14	14.69	13.46	12.24	11.02	9.79	8.57	7.34	6.12	4.90
16	12.85	11.78	10.71	9.64	8.57	7.50	6.43	5.35	4.28
18	11.42	10.47	9.52	8.57	7.62	6.66	5.71	4.76	3.81
20	10.28	9.42	8.57	7.71	6.85	6.00	5.14	4.28	3.43
22	9.35	8.57	7.79	7.01	6.23	5.45	4.67	3.89	3.12
24	8.57	7.85	7.14	6.43	5.71	5.00	4.28	3.57	2.86
	LCOE: P/kWh								

4.5 peak-hrs/day	Panel cost, P/kWp								
Panel life, years	60,000	55,000	50,000	45,000	40,000	35,000	30,000	25,000	20,000
6	30.46	27.92	25.39	22.85	20.31	17.77	15.23	12.69	10.15
8	22.85	20.94	19.04	17.14	15.23	13.33	11.42	9.52	7.62
10	18.28	16.75	15.23	13.71	12.19	10.66	9.14	7.62	6.09
12	15.23	13.96	12.69	11.42	10.15	8.89	7.62	6.35	5.08
14	13.06	11.97	10.88	9.79	8.70	7.62	6.53	5.44	4.35
16	11.42	10.47	9.52	8.57	7.62	6.66	5.71	4.76	3.81
18	10.15	9.31	8.46	7.62	6.77	5.92	5.08	4.23	3.38
20	9.14	8.38	7.62	6.85	6.09	5.33	4.57	3.81	3.05
22	8.31	7.62	6.92	6.23	5.54	4.85	4.15	3.46	2.77
24	7.62	6.98	6.35	5.71	5.08	4.44	3.81	3.17	2.54
	LCOE: P/kWh								

121 $(5{,}000 \times 55 \times 1.25) + (5{,}000 \times 55 \times 3) = 1{,}169{,}576$.

122 $0.85 \times 5 \times 4.5 \times 365 \times 20 = 139{,}612.5$ kWh.

5.0 peak-hrs/day		Panel cost, P/kWp								
		60,000	55,000	50,000	45,000	40,000	35,000	30,000	25,000	20,000
Panel life, years	6	27.42	25.13	22.85	20.56	18.28	15.99	13.71	11.42	9.14
	8	20.56	18.85	17.14	15.42	13.71	11.99	10.28	8.57	6.85
	10	16.45	15.08	13.71	12.34	10.97	9.60	8.22	6.85	5.48
	12	13.71	12.57	11.42	10.28	9.14	8.00	6.85	5.71	4.57
	14	11.75	10.77	9.79	8.81	7.83	6.85	5.87	4.90	3.92
	16	10.28	9.42	8.57	7.71	6.85	6.00	5.14	4.28	3.43
	18	9.14	8.38	7.62	6.85	6.09	5.33	4.57	3.81	3.05
	20	8.22	7.54	6.85	6.17	5.48	4.80	4.11	3.43	2.74
	22	7.48	6.85	6.23	5.61	4.98	4.36	3.74	3.12	2.49
	24	6.85	6.28	5.71	5.14	4.57	4.00	3.43	2.86	2.28
		LCOE: P/kWh								

Source: Author's calculations

Chapter 26
Who wants to be a showcase?

The specific focus of this study is identify and subsequently help villages and towns make the full transition to a renewable future without using fossil-fuels, nuclear plants, and other dirty, dangerous and non-renewable sources.

While this study is fully supportive of individual solar, wind, small hydro, biomass and other renewables, we need to go beyond these individual projects. We need to show that *we can make the energy transition now*, *village by village*.

In this transition, a special role will be played by local executives who are willing to take—or have already taken—the lead in setting up a renewable energy project. For one thing, with a buy-in by the local government, the problem of social acceptability is already half solved.

A renewable energy roadmap for local governments

We propose the following RE roadmap for LGUs who want a showcase set up in their locality:

1. On the first year: they should display political will regarding an RE showcase, by allotting a sufficient amount in their budget for a one-year study on the feasibility of an RE showcase in their locality, and simultaneously installing a properly-sized solar PV system in their municipal hall.

   The study would include a year-round monitoring and recording and verification of wind, solar and hydroelectric resources as predicted in various wind/solar mapping projects for the Philippines. It would also include a financial feasibility study, and if determined to be viable, a project design that can be submitted to potential investors and lenders.

The 13-MW Sacasol project took two years to progress from project conceptualization to project operation.

The municipal hall's solar PV system will feed into the feasibility study and immediately validate or modify some of the assumptions and findings of the study. Municipal officials should also negotiate with the local utility for the implementation of true net metering, which will significantly increase the savings.

2. Bid out the conduct of the feasibility study to RE contractors, universities and other qualified organizations. Bid out or negotiate the purchase of the solar PV system.

3. On the second year: once financial feasibility is determined, LGUs should invite investors and, if it deems appropriate, invest its own equity in the project.

4. Apply for a service contract for the RE projects. (Note that DOE took only 12 days to process the application of SACASOL, the first RE project to go online.)

5. Facilitate the issuance of local business permits and licenses.

6. Open for bidding, choose the winning bidder, construct and install.

7. On the third year: Start operations! (Note that it took SACASOL two years to progress from project conceptualization to project operation.)

We already have many localities that host at least one renewable technology, such as a solar farm, wind turbines, and small hydro, or a biomass-fueled generating plant. They are one step ahead of the rest in making the transition. Their executives and local councils need to expand their horizon and think farther into the future. They need to dream about a future that they want for their grandchildren. And they need to make that dream come true.

The dream of clean, renewable and cheap energy is within our reach. That dream is not only ours. It is the dream of many. We only need to exert the final effort and reach out, and that dream will become reality. The author set up the Center for Renewable Electricity Strategies (CREST) in 2015 precisely to support local governments in this endeavor.

There is no doubt, that the first localities in the Philippines that will make the energy transition to 100% renewable electricity will become true showcases in sustainable living for the country. People will want to visit the area (eco-tourism); other local government officials will want to replicate the experience (model municipality); and the national polity will take notice.

We call on every local as well as national official to make this dream of a full energy transition your dream too. You have the means to turn it into reality.

Chapter 27

The electric grid of the future

In the future, the electric grid will appear more like the Internet—an internetwork of networks of electricity stakeholders that include big and small consumers, and big and small producers, including big and small stakeholders who may buy electricity from the grid some of the time and sell electricity to the grid at other times.

As built-in intelligence, processing power, memory and other technological improvements developed for the Internet are also deployed for the electric grid, the various sources and sinks of electricity will be able to negotiate among themselves. They will be able to keep account of how much they are getting from the grid, at what price, and how much they are feeding into the grid, at what price.

The grid will be more like the Internet—networks of bigand small electricity stakeholders who may buy from the grid some of the time, and sell to the grid at other times.

In parallel with the electronic Internet (the Internet of information), we will have an electric Internet (the Internet of energy).

The energy Internet, like the information Internet before it, will see two conflicting trends: the client/server model, and the peer-to-peer model.

The Internet of information was designed as a peer-to-peer network—and began as such—with universities and governments connecting to each other as network peers (though they may not have been peers as far as resources were concerned). Once one had an IP address, one had a host on the Internet that could send or receive files and mails to any other host.

Gradually, however, a different kind of model was superimposed on this peer-to-peer model (which remains at the foundation of the Internet). This superimposed model was the client/server model, in which a few servers provided services for many clients. Instead of peer-to-peer exchange of files and mails (which can still be done today, if users would learn how to do it), users were drawn by convenience to surrender their peer status. They then became clients relying on large servers for file and mail services and all their derivatives. (It is less simple at the technical level, as client/server approaches may be employed in the context of the peer-to-peer model, where one side acts as server in one aspect of a connection, and as a client on another aspect of the connection.)

With the US National Security Agency working hand-in-glove with the largest file and mail servers on the Internet to monitor the private lives of individuals all over the globe, peer-to-peer networking is currently enjoying a healthy and well-deserved revival, turning the choice of models into a socio-political debate about centralized and decentralized approaches.

In the earliest days of electricity, like the early days of computing, the client-server approach held sway. The electric Internet was based on the client/server model from the beginning of its growth, with large utilities providing electricity as a service to consumers as their clients.

The growth of solar energy generated with PV panels is now making it possible for households to generate electricity *at a lower cost* than large-scale utilities that have to tack on to their generation charge various other charges such as distribution charges, systems losses, universal charges and other mysterious expenses that the hapless consumer can hardly figure out. In Germany, there are already 1.2 million households who have invested in PV technologies, having obtained bank financing to take care of the high up-front costs of solar investments. They went solar because they realized they can sell electricity to the grid and make money. In fact, during peak hours, it makes more economic sense for them to sell all their PV production to the grid—at premium FIT rates.

When millions of electric vehicles go online and connect themselves to the electric grid, not only to buy electricity but also to sell it during peak hours, they will further significantly expand the social base for the peer-to-peer model in the emerging electric Internet. Technical developments in storage batteries which may not be good enough for mobile applications such as phones, laptops and electric vehicles, may serve perfectly well for distributed storage of electricity. This creates a much larger market for such batteries and providing battery makers better economies of scale.

The peer-to-peer versus client/server trends will continue to battle it out in the Internet of information and the Internet of electricity.

Thus, the peer-to-peer versus client/server trends will continue to battle it out, both in the Internet of information and the Internet of electricity.

Many of us have participated in three major intertwined technological revolutions in our lifetime.

The first was desktop computing which literally put a computer in almost every desktop, in almost every urban home.

The next was the Internet, which connected our desktop computer to millions of others, enabling us to expand our educational, cultural, economic and political horizons and reach in ways that we could not even imagine a decade ago.

The third was the mobile revolution, which turned the telephone into a personal communicator now morphing into something that does not even have a proper name yet.

We are now at the threshold of the fourth revolution, that will soon empower every household to generate its own electricity cheaply from the sun.

If you can't see it happening yet, visit the sidewalks of Raon in Quiapo, Manila, for a glimpse of the future. In the Philippines, Raon contains the highest concentration of vendors for electronic parts and supplies. Today, you will find in Raon solar panels being sold on the sidewalks. The sale of solar panels (up to 300-Wp panels) and deep cycle batteries on sidewalks by street vendors suggests that solar PV profit margins have become large enough to support more than one layer of the supply chain. Just as the proliferation of retail outlets ushered the computer desktop and later the mobile phone mass market, this is another indication of the emerging mass market for solar PV.

Figure 18: Solar Panels Sold in Sidewalks of Raon, Quiapo, Manila

Source: Photo by Author.

The fifth revolution will come when reliable energy storage—probably not the lead-acid battery—likewise becomes cheap enough to sell not only in Raon but also in mom-and-pop stores throughout the country.

Indeed, we live in challenging times.

Unfortunately, there are dark clouds on the horizon too.

Chapter 28
Coping with oil insecurity, global warming

Two defining global problems confront our era: oil insecurity and global warming. Both are the culmination of more than a century of burning fossil fuels without regard for conserving resources for the needs of future generations nor for the Earth's capacity to absorb industrial emissions.

Oil insecurity [123]

Oil insecurity is often described in terms of "peak oil", which refers to the highest level of production in the oil industry. Many experts have conceded that peak oil will probably happen in the next decade or two, if not in this one. Beyond peak oil, production will plateau, then gradually decline.

When oil supply tightens, we can expect a bidding war—perhaps even a shooting war—for control over the world's oilfields.

The commercial exploitation of new oil sources, such as the Canadian tar sands, Brazilian pre-salt, North American tight oil (also called shale oil), kerogen-rich oil (also called oil shale) and other unconventional sources of oil[124] has led in the past few years to a downward trend in oil prices. These new sources may delay the onset of peak oil, but will not stop it. They will also result in more local pollution and greenhouse gas emissions. Worse, they can lull economies and governments into a "business-as-usual" attitude and postpone the implementation of badly-needed measures to wean the world away from fossil fuels and arrest global warming.

123 Many books have been written on this topic. See for instance Paul Roberts, *The End of Oil: The Decline of the Petroleum Economy and the Rise of a New Energy Order.* (London: Bloomsbury, 2004). See also Daniel Yergin, *The Quest: Energy, Security, and the Remaking of the Modern World.* (New York: The Penguin Press, 2011).

124 Yergin, pp. 252-262.

There are many who do not believe that peak oil is a major problem for our generation, but who nevertheless acknowledge a “liquid fuel” problem, or an “oil shortage”. Take UCBerkeley physicist Richard Muller, for instance. Muller believes in nuclear power, hydraulic fracturing (fracking), and the widespread extraction of shale gas and oil. He also believes that the BP Gulf oil mega-spill as well as the nuclear explosions in Chernobyl and Fukushima were bad but not catastrophic.

As for peak oil, Muller writes: “The true energy crisis in the United States, and much of the rest of the world, derives predominantly from two issues: energy security and global warming. The security problem comes not from an energy shortage (we have plenty), but from an oil shortage—more precisely, from the growing gap between domestic petroleum production rate and the demand for gasoline, diesel, and jet fuel.”[125] Muller emphasizes: “We don't have an energy crisis; we have a transportation fuel crisis. We don't have an energy shortage; we have an oil shortage. We not running low on fossil fuels; we're running low on liquid fuels.” [126] [Emphasis in the original]

Call it “oil shortage,” “liquid fuel shortage,” or “peak oil.” We call it oil insecurity. When the oil supply tightens and eventually plateaus (worse, when it declines), while demand continues to rise to satisfy the fuel-thirsty economies not only of US, Europe, Japan and Russia, but also of China, India, Brazil and South Africa—not to mention the rest of the world—then a bidding war for the limited supply will drive oil prices up.

To ensure supply, some countries may resort to military action. Then a shooting war may erupt. Countries will go to war for oil—we can already see that today. What will happen then to those countries like the Philippines who neither have the wealth to bid for oil, nor the military power to fight for it?

By shifting to renewable resources, which are all locally available, we are also ensuring a peaceful future for our children and grandchildren.

Global warming

Global warming is a direct result of the world's unquenchable thirst for oil and other fossil fuels. It will keep getting worse, if shale oil and similar alternatives are exploited on a large scale. In turn, global warming is resulting in climate change, coastal flooding and more extreme climate events.

Given its long coastline and its location in the typhoon belt, the Philippines is one of the countries that will have to bear the worst impacts of this problem. Typhoon Yolanda (international name: Haiyan) in 2013 is just a preview of the kind of disasters that global warming will bring.

The point of no return for global warming will probably happen in this decade, if it is not already happening. Beyond that point, we will

Our grandchildren will have a hard time surviving in this very different world of encroaching sea levels, extreme weather events, and threatened ecosystems.

125 Muller, p. 291.
126 Muller, p. 102.

be swept in global warming's vicious cycles. Melting snow will reduce the reflectivity of the poles and this will speed up the warming. Further warming will reactivate the decomposition process in erstwhile frozen soils as they warm up. This will then release more greenhouse gases that cause more warming. Long buried over eons, methane in the oceans may be released, triggering new vicious cycles. Our grandchildren will have a hard time surviving in this very different warming world of encroaching sea levels, extreme weather events and threatened ecosystems.[127]

You can easily and quickly do today one single practical act to help make our world more peaceful and more livable: **shift to LED lights and put solar panels on your rooftop.**

Fortunately, there is a way out—but only if we take it soon. An immediate shift to renewables will keep peak oil at bay for a while, perhaps for good. Then we do not have to worry about going to war to get our share of oil fields. Phasing out fossil fuels will gradually—ever so gradually—slow down the rising CO_2 levels in the atmosphere. Hopefully, decades after, perhaps centuries after the levels of greenhouse gases in the atmosphere stabilize, the climatic and ecological balance that used to envelop our world will return.

If you were asked to make a single practical act to help make our world more peaceful and more livable, there is one thing you can do, easily and quickly: shift to LED lights and put solar panels on your rooftop today. Encourage your neighbor to do it too. Do not stop telling others, until every single fossil-fueled plant in the country has ground to a stop.

127 The clearest description of the impacts of global warming for every degree rise in average global temperatures is still Mark Lynas, *Six Degrees: Our Future on a Hotter Planet.* (Washington, DC: National Geographic, 2008). The most authoritative book on global warming and climate change is of course the IPCC Assessment Reports, the latest of which were issued in 2013 and can be downloaded for free at https://www.ipcc.ch/report/ar5/.

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