Turku University of Applied Sciences

Degree Programme in International Business

Bachelor’s Thesis

2016

Mohamed El-Fatatry

FACTORS CATALYZING WIDESCALE ADOPTION OF SOLAR TECHNOLOGIES

– Market Analysis for Masar

TURUN AMMATTIKORKEAKOULU
TURKU UNIVERSITY OF APPLIED SCIENCES

BACHELOR´S THESIS | ABSTRACT
TURKU UNIVERSITY OF APPLIED SCIENCES

Degree Programme in International Business

1.6.2016 | 35 Pages

Advisor: Alberto Gonzalez

Mohamed El-Fatatry

FACTORS CATALYZING WIDESCALE ADOPTION OF SOLAR TECHNOLOGIES

The world is undergoing a massive climate crisis: In 2015, record high temperatures occurred (The Weather Channel, 2015), millions of refugees have left their homelands due to poverty, weak crop yields and civil war (UNHCR, 2015), and hostile politics are at the center of a new fossil fuel field discovery crisis in the Mediterranean sea (The Regional Center for Strategic Studies, 2015). Furthermore, energy prices are predicted to continue increasing (IEA, 2015), CO2 emissions have been flagged as the primary cause of climate change (IEA, 2015) and over 1 billion people have no access to basic electricity (TIME, 2013). Meanwhile, a technology has existed for decades that promises to deliver reliable, limitless and CO2 emission-free energy to the world. Despite the fact that this technology has made great progress in recent years, it still only supplies less than 1% of the world's power (IEA, 2014).

This thesis will examine the factors catalyzing widescale adoption of solar technologies, namely solar Photovoltaics (PV) + storage, with a special focus on the role convergence between electricity consumers and producers, by observing and interviewing energy experts from around the world. The research examines whether the developing world, with Egypt as an example, is most likely to experience a breakthrough in solar adoption during the coming years.

The research also attempts to combine different perspectives from industry experts, academics and entrepreneurs to reveal trends about the adoption of solar technologies. Wherever possible, actionable conclusions will highlight the most influential factors and players in the ongoing solar energy revolution as well as the author's predictions about the future of this technology and the developments in financing relating to this market. Finally, the conclusion will provide some predictions on the growth of solar & storage adoption, whether the world will meet its solar deployment targets and which regions are more likely to grow faster than others.

KEYWORDS:

Solar power, Photovoltaics, Renewable energy production, Solar storage.

TABLE OF CONTENTS

FIGURES

LIST OF ABBREVIATIONS (OR) SYMBOLS

CO_2	Carbon dioxide
PV	Photovoltaics, a type of chrystalline silicon panels which generate electricity when exposed to sun rays.
FiT	Feed-in-Tariffs paid for power generated into the grid
PPA	Power Purchase Agreement detailing the terms (such as price and time period) of electricity purchase
EV	Electric Vehicle
Wh	A unit of energy equivalent to one watt (1 W) of power expended for one hour (1 h) of time
Wp	A unit of the nominal output of a photovoltaic system
IEA	International Energy Agency
GSB	Global Sun Belt
Peak-shaving	Grid optimization technology used for balancing supply & demand.
Prosumer	An entity that both, consumes and produces electricity.
Home storage	Batteries used to store electricity during low-demand hours and to be used during peak hours.
TPO	Third-Party-Ownership, also known as solar leasing
Utility	An organization supplying a community with electricity, gas, water, or sewerage treatment.
Leapfrogging	Technology leapfrogging is the bypassing of technological stages that other regions or countries have previously gone through.

1 INTRODUCTION

During the summer of 2014, the author (who is a dual Finnish-Egyptian citizen) visited Egypt (which sits on the sun-rich Global Sun Belt, as shown in Figure 1) after spending all his life abroad. In Finland and the rest of Europe, residents are accustomed to high quality infrastructure services such as electricity, heating and water but in Egypt, the situation was different. After three years of revolutions since 2011, a shortage of fossil-fuels sparked by a foreign currency crisis was causing power blackouts on a daily basis. Such power blackouts disrupted daily life and dissipated a significant number of productive hours which the country needed in order to improve its economy. Meanwhile, Egypt enjoys an average of 3,451 hours of sunlight per year (ClimaTemps, 2014) with an average potential of over 2,000KWh of solar energy per m2 per year (Land Art Generator Initiative, 2015). Given that Egypt's total electricity consumption per year is 136TWh (CIA World Factbook, 2015) and its land area is 1M km2, this means that covering only 6.8% of its land with solar panels would produce 100% of its electricity needs with today's technology.

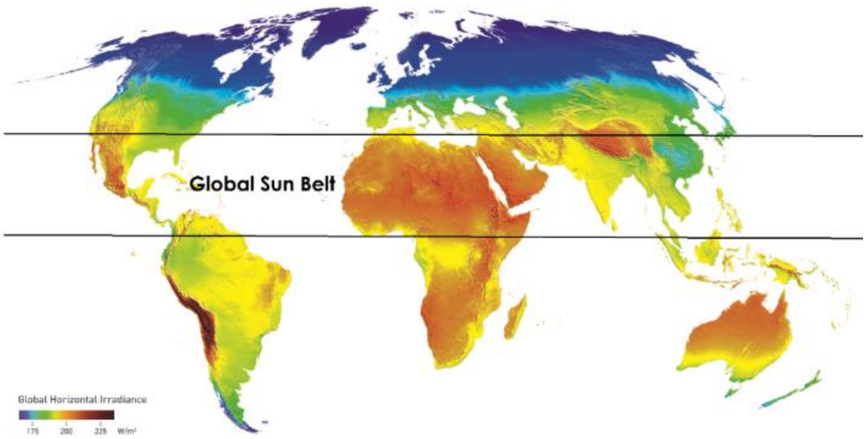


Figure 1: Masar's Global Sun Belt (Masar, 2015)

This situation led the author to explore the potential of solar power to solve Egypt's (and other developing countries') power problems. This is especially interesting given that the world's first solar power plant was built in Cairo by American inventor Frank Shuman in 1916 (New York Times, 1916) but the adoption of solar technology has been slower in Sun-rich regions like Africa than other less-sunny parts of the world like Western Europe (SolarPower Europe, 2015). Even though some solar panel installers have existed in Egypt for some 30 years, consumers did not have the funds or the know how to take the lead in adopting solar technologies despite solar panels dropping in price by two thirds in the last six years (IEA, 2014).

In this context, this thesis will examine the primary drivers of widescale solar technology adoption by consumers, producers (including developers and investors) and governments as well as the ongoing convergence between electricity consumers and producers. It will also examine the role of solar storage as a secondary technology enabler and how fast developing countries, such as Egypt, could adopt solar energy on a widescale.

This exploratory research will guide the market activities of Masar (which was founded by the author), a global smart energy company headquartered in Amsterdam - Netherlands with offices in Helsinki - Finland, Cairo - Egypt and a factory in Frankfurt - Germany. The company specializes in deploying mobile solar installations on the Global Sun Belt (GSB) and generates revenues primarily from the power generated. The company was started as a collaborative project within Turku University of Applied Sciences in 2014 and has since then attracted international investors and launched its activities across 5 countries. The company has been chosen among the Top 30 Most Promising Energy companies in Europe 2016 by Energy Week and among the Top 40 ALPHA 2016 startups by Collision.

1.1 Research Objectives & Questions

The research objective is to analyze a general market trend that can guide Masar's activities. Therefore, the research will focus on the following objectives:

- **To assess which market segments will drive the growth of solar adoption and whether the growth will be primarily driven by market dynamics (such as demand, cost, etc.) or by public policies.**

- **To assess whether the role convergence between consumers and producers is a pre-requisite to widescale adoption of solar technologies, and what role solar storage will play in the transition.**

- **To assess whether the developing world, such as Egypt for example, can enjoy a quicker transition roadmap due to the nonexistence of conventional grids and/or the existence dysfunctional grids.**

The research objectives shall be achieved by answering the following questions:

1: What are the interesting trends driving solar adoption and are they policy-driven, technology-driven (such as lower cost) or market-driven?

2: Which trend-setters (including consumer-producers or “prosumers”) are leading the adoption of solar technologies?

3: What are the global regions most likely to experience a breakthrough in the utilization of solar technologies in the next decade?

2 BACKGROUND

As the solar industry is still at its infancy, supplying less than 1% of global electricity (International Energy Agency, 2015), the author is interested in exploring the state of solar technology as well as organic (due to market demand for self-consumption of solar power) and non-organic (due to government incentives, Feed-in-tariffs or subsidies) growth factors. The renewable sector has been one of the fastest growing sectors around the world, creating more than twice the number of coal miner jobs in the US (Fortune, 2015).

Masar has provided the author unprecedented access to global events focusing on the renewable energy transition including the World Future Energy Summit (Abu Dhabi), Smart Energy Summit (Amsterdam), Global Cleantech Summit (Helsinki), Solaire Expo Maroc (Casablanca), Ecosummit (Berlin, London), Solar Power North Africa (Cairo), TBLI Conference (Zurich), SolarPower Europe Convention (Brussels), Collision (New Orleans) among others. The author also sits on SolarPower Europe's "Task Force on Solar Storage", which includes the most influential solar companies in the world (such as Canadian Solar, Enphase, EUROBAT, etc.) and directly advises the European Commission on solar-related market trends and policies. This exposure has provided a unique opportunity to observe different perspectives and detect active trends in the energy transition.

One of the commonly held beliefs among industry experts is the end of the fossil-fuel era. According to energy strategist Jochen Wermuth, oil would have to fall to $7 a barrel (the 2017 forecast of oil price is $57/barrel according to Oil-price.net) to compete with the lowest accepted tender for solar power as low as $0.03/KWh (Bloomberg New Energy Finance, 2016). The political volatility of oil is an even bigger problem that can catalyse the transition towards renewables as the most powerful oil lobby, the Organization of the Petroleum Exporting Countries (OPEC) has become weakened and unable to stabilize global oil prices, as predicted long ago by Hubbert's peak oil theory (Greene, 2003). However, there is no clear consensus on whether the energy transition will happen at a different pace for different regions as for example, Europe has been focused on distributed solar power generation while China has proposed a global super-grid that can share excess capacity between participant countries in real time (Global Energy Interconnection, 2015).

Historically, self-consumption of solar power took off first before subsidy-driven incentives such as Feed-in-Tariffs (where the government pays for electricity produced and fed into its grid) were put in place, mainly by electricity consumers who had no access to the grid (Masar, 2015). But in the last 15 years solar adoption has been mainly fueled by government incentives (Institute for Building Efficiency, 2010). Now, after several countries reversed or retroactively taxed their generous incentives, this could signal a come-back for the organic self-consumption trend, especially with the availability of affordable solar storage systems such as the Tesla Powerwall and Sonnen Eco (SolarPower Europe, 2015) which will be examined.

Another key focus of this thesis is the role of the consumer-producer, or ”prosumer” in the future energy landscape. Prosumers are entities that are both consumers and producers of electricity (Toffler, 1980). This includes small and medium prosumers with Photovoltaic (PV) panels, smart electricity meters, back-up battery systems, EV-to-grid systems and other smart appliances.

This new era fundamentally changes the economics of energy utilization in the following way. As the number of prosumers rises, electric utilities will be forced to re-define themselves as an enabler of a stable grid as opposed to a monopoly producers and transmitters of electricity (SolarPower Europe, 2016). Other services will most likely be introduced to compensate for lost revenue from this new competition and massive asset write-downs. For the first time since electricity was discovered, prosumers are directly competing with utilities, causing a widescale reshuffle of influence in the energy markets.

Finally, the research examines what role utilities will play in the future in terms of added services such as EV-charging stations, Wide-area Wi-Fi and grid optimization (peak-shaving, utility-scale storage, etc.), paving the way for a new kind of “Super-Utility” (DEMOS Helsinki, 2015). Such Super-Utilities have the potential of providing superior service packages to consumers and prosumers for a fraction of the price of conventional utilities.This may happen as a result of leapfrogging (i.e. skipping one or more steps in the technology adoption curve) by developing nations, who are now accessing renewable power for the first time without first going through the a conventional grid. According to Fortum CEO Pekka Lundmark, the telecom industry has experienced such a trend during the early 21st century as the developing world entered the mobile era without going through landline technology first. Hence, his company announced a push towards renewable energy in emerging markets (Fortum, 2016).

2.1 Research Methodology

As this field of research is relatively new, qualitative data from the author’s own observations as well as interviews will be analyzed to come up with intuitive conclusions, rather than incrementally building on existing work. The exploratory qualitative research (Saunders, 2000) will focus on the observation of a number experts in solar technologies, energy policy and market economics and interviews during industry events as well as casual conversations and/or interviews conducted face-to-face, by phone or by email.

Due to the abundance of qualitative information, but a lack of concrete conclusions, the inductive approach was selected. In inductive reasoning, the premises are viewed as supplying strong evidence for the truth of the conclusion (Copi et. al., 2007). Hence, the conclusion of an inductive argument is probable (not certain), based upon the given evidence.

Furthermore, according to Saunders et. al. (2009), the condensation of meaning is a type of valuable output from qualitative analysis. This implies summarizing large amounts of text into shorter form while becoming more familiar with the collected data is one of the goals of academic research. Thomas (2003) has similarly highlighted the same advantages of the inductive approach: “(1) to condense extensive and varied raw text data into a brief, summary format; (2) to establish clear links between the research objectives and the summary findings derived from the raw data and (3) to develop of model or theory about the underlying structure of experiences or processes which are evident in the raw data”. (Thomas, 2003) The theoretical framework connecting the research to existing academic work will come after the research analysis.

As suggested by Thomas' (2003) this approach works well with exploratory research as it enables the researcher "to allow research findings to emerge from the frequent, dominant or significant themes inherent in raw data, without the restraints imposed by structured methodologies". Since the research objective is to analyze a general market trend that can guide Masar's activities, no predetermined propositions were made on the basis of the theoretical framework. It was decided with the thesis advisor to avoid the limitations of theoretical propositions which do not take into account the participants' unique experiences (Bryman, 1988).

2.2 Observation

This research will use observation as the primary method of data collection and in particular, researcher participation technique where the author is equally immersed into the research setting as the subjects to get a finer appreciation of the phenomena (Spradley, 1998). To achieve this, the author has attended over 50 keynote speeches covering various perspectives of the energy transition from both fossil-fuel and renewable-energy experts.

This method is closely akin to autoethnography, which according to Ellis et. al. (2011), is an approach to research and writing that seeks to describe and systematically analyze personal experience of the participants. This approach challenges canonical ways of doing research and representing others and treats research as a political, socially-just and socially-conscious act. A researcher uses tenets of autobiography and ethnography to do and write autoethnography. Thus, as a method, autoethnography is both process and product. (Ellis, 2011)

2.3 Interviews

Unstructured interviews of industry experts is an additional data collection method utilized during this research to fill gaps encountered from exploratory observation. During these unstructured interviews, the participants are granted the freedom to answer the questions in order or within casual conversation and only sometimes notes will be taken if it does not interfere with the flow of the conversation or make the interviewee uncomfortable. The main point is not to control the flow of information, but rather dig deeper into their subjective experiences and unveil special anecdotes they may have experienced.

The following experts were interviewed during the research:

- **Torsten Schreiber, Energy entrepreneur, Africa GreenTec**
  - Africa GreenTec is a German manufacturing company based in Frankfurt, focusing on the electrification of rural Africa.
- **Jochem Wermuth, Cleantech energy strategist, Wermuth Asset Management**
  - Wermuth Asset Management is a family-owned wealth management company that has announced a complete divestment from fossil-fuel assets and a 100% shift towards renewable energy assets.
- **Atter Hanoura, Director of PPP, Egyptian Ministry of Finance**
  - The Egyptian Ministry of Finance office of Public Private Partnership is a governmental department that influenced the creation of the Egyptian Feed-in-Tariff legislation and oversaw drafting of solar PPA agreements.
- **Juha Saarinen, Cleantech investor, Avanto Ventures**
  - Cleantech investor and board professional involved in several cleantech companies such as Ekorent, Joukkonvoima and Masar.
- **Sameer Halai, Energy entrepreneur, Sunfunder**
  - Co-founder of solar funding platform Sunfunder that has successfully deployed more than $5m in capital to solar projects in Africa. Historically, 100% of the projects provided a pay-back time of less than 5 years.
- **Dr. Valtteri Kaartemo, Academic scholar, Turku School of Economics**
  - International Business lecturer at Turku School of Economics whose main research interests include networks and processes in the field of service research, international entrepreneurship and energy sector market dynamics. In 2015, he became the head of Masar Academy, the research arm of Masar.

Note: The original topic of the thesis was focused on factors preventing widescale adoption of solar technologies where the author tried to discover why solar still only supplies a small percentage of global electricity. However, during the research work many factors have been eliminated as the world had signed the historic ”Paris Climate Agreement” in December 2015, hence, the topic was changed to its current form to focus on factors catalyzing such adoption. Furthermore, the author presented some of the key findings of this research at Energy Fest in the Shell Technology Centre, Amsterdam on May 26th 2016. Accordingly as this kind of research is new and quite rare, he has been named one of the Leading Innovators in the Renewables & Storage sector (Appendix 1).

3 RESEARCH ANALYSIS

Recent publications have reported increasing activity by public institutions like the Indian Government (Solar Love, 2015) and African Development Bank (Bloomberg New Energy Finance, 2015) to accelerate solar technology adoption, which are strong signs that the developing world is rapidly accelerating torwards renewables. In fact, the Frankfurt School-United Nations Environment Program reveals that global renewable energy investments in the developing world ($155.9 billion) have already surpassed similar investments in the developed world ($130.1 billion) in 2015 (FS-UNEP, 2016).

Even though some macro-research has been conducted on this topic (e.g. Neij, 2007), many of the existing literature lacks a qualitative perspective; real stories by real people whose pioneering actions can be a strong inspiration for the rest of the industry. As we have seen throughout history during the early days of a new market, the unique approaches of a pioneering team can have a lasting effect on its development such as the universal use of AC instead of DC current in electricity grids (Masar, 2016).

The following is an example of a widely held belief in the solar industry (SolarPower Europe, 2016) without actionable conclusions.

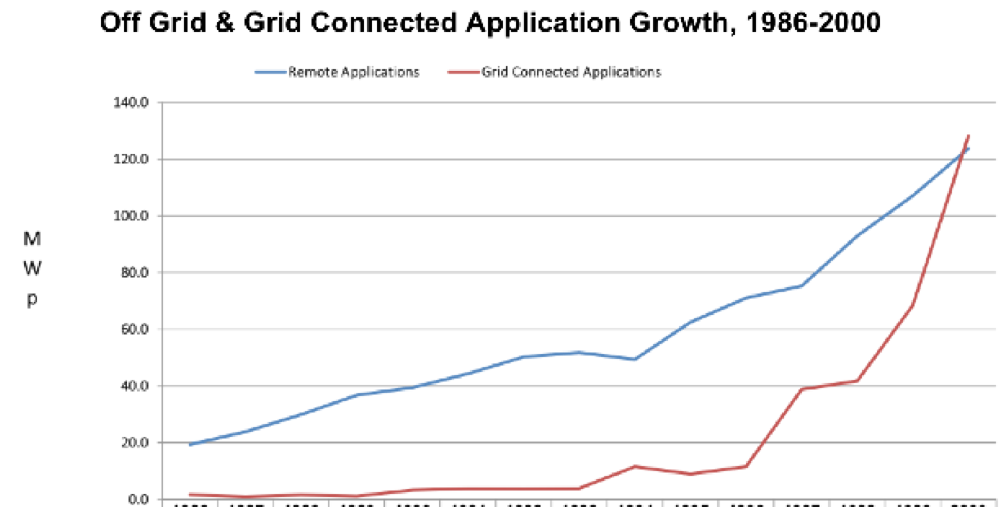
Figure 2: Europe PV electricity 2015-2050 (Agora Energiewende, 2015)

Agora Energiewende claims that solar will be the cheapest source of electricity by 2050 as shown in Figure 2. In order to explore this further the following factors will be considered.

Firstly, will this be based on current Photovoltaic (PV) technology or a new breakthrough? What role will storage play in this roadmap? Will sun-rich countries have a different lifetime cost of electricity due to higher yield from the same asset investment? Secondly, the majority of solar production in the world today is subsidy-driven, not self-consumed. But with the rise of electricity prices globally and blowbacks from various governmental Feed-in-Tariff and incentive programs will this change dramatically in the coming years? Thirdly, the question we attempt to answer is not whether the fossil-fuel era will end, but how soon and what the implications for consumers, producers and governments from this transition will be?

3.1 Worldwide Growth of Photovoltaics (PV)

Tesla CEO, Elon Musk: "Every square kilometer receives 1 GWp of solar energy per day. If you place solar panels on the surrounding land of every nuclear power plant, you would get more electricity without nuclear waste."



	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Remote Applications	19.3	23.9	29.9	36.8	39.4	44.3	50.3	51.8	49.4	62.5	71.0	75.3	93.0	107.1	123.8
Grid Connected Applications	1.7	1.0	1.6	1.1	3.3	3.9	3.8	3.9	11.6	9.0	11.6	38.8	41.8	68.4	128.2

Figure 3: Off-Grid & Grid Connected PV (Renewable Energy World, 2013).

As we can see in Figure 3, since the year 2000, most of the world's Photovoltaic installations have been grid-connected and thus policy-driven. According to

Cleantech investor Juha Saarinen the electricity must be fed into the grid, and then consumed back, or consumed by others. This introduces complexity and inefficiency and makes it harder for prosumers to invest in solar assets, as they would still not become grid-independent or reduce their expenses immediately. Consumption subsidies, Feed-in-Tariffs and Net Metering schemes (where produced electricity is deducted from consumed electricity before utility invoicing) do not encourage self consumption of produced electricity.

Moreover, in some countries, self-consumption is even penalized while Feed-in-Tariffs have been rolled back thus rendering investment in renewables costly and inconvenient. However, most countries still do not have clear policy regarding prosumers where even in Europe, a single economic and political region, some countries penalize for self-consumption of solar power, while others incentivize self-consumption and the rest of the countries do not have any policy regulating self-consumption. (Task Force on Solar Storage, 2016)

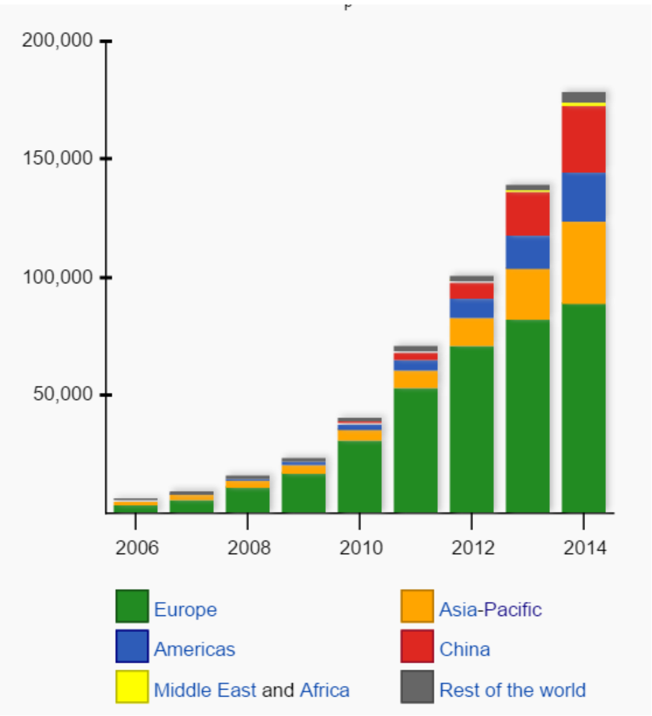


Figure 4: Woldwide growth of PV (SolarPower Europe, 2015; IRENA, 2015)

Despite such challenges, renewable energy capacity has grown since from 40GWp in 2010 to more than 233GWp in 2015 as shown in Figure 4. Even though most of today's capacity is installed in Europe, other regions such as Asia Pacific, China and the Americas are also picking up the pace. It is also expected, that Africa & the Middle East will become major players in the renewable space within the next decade due to low electrification rates, the non-existence of a conventional grid and the abudance of solar energy (FS-UNEP, 2016). Due to economies of scale, this will reduce the price of solar technology and drive further adoption (Sullivan, 2003). This will be further explained in 3.4.

3.2 Decreasing Cost of Photovoltaics

According to Agora Energiewende (Figure 8), the cost of Photovoltaic (PV) technology is expected to fall below \$0.02/KWh by 2050 in the most optimistic scenario. This would make solar technology the cheapest form of electricity production known today and would diminish reliance on fossil-fuels significantly. This estimate is based on current Photovoltaic technology, but with an expectation of a breakthrough in cost-reduction. Even in the most pessimistic scenario, solar is expected to fall to around \$0.04/KWh which would still make it cheaper than most other technologies for sun-rich countries.

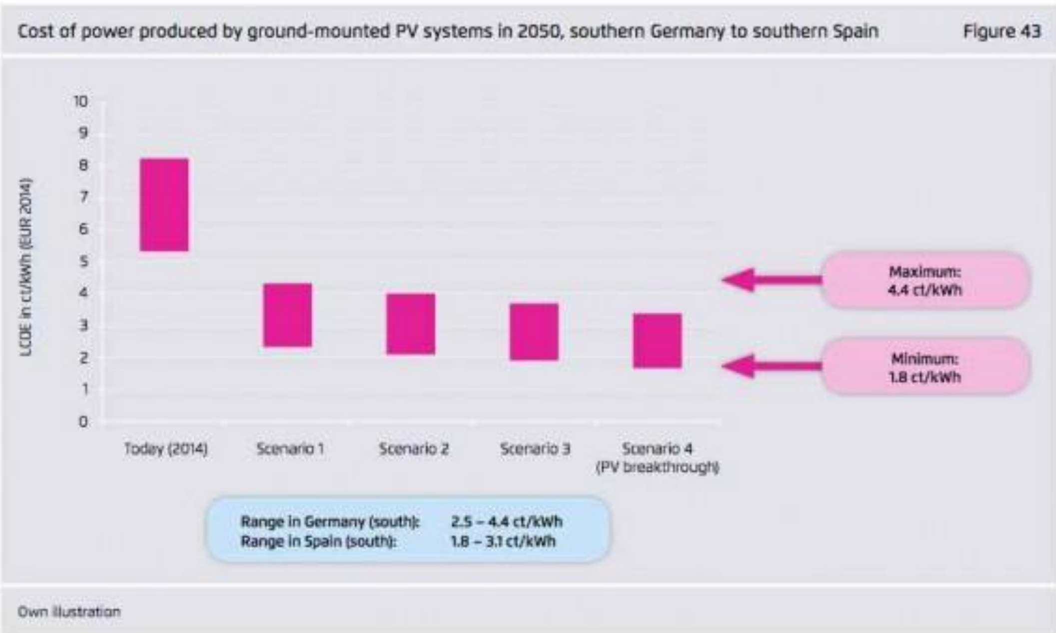


Figure 5: Cost of PV in 2050, 4 scenarios (Agora Energiewende, 2015)

According to Juha Saarinen, the discovery of “perovskite” solar cells may indeed be the breakthrough necessary to reduce the price of solar significantly with some companies promising commercial perovskite panels in early 2017.

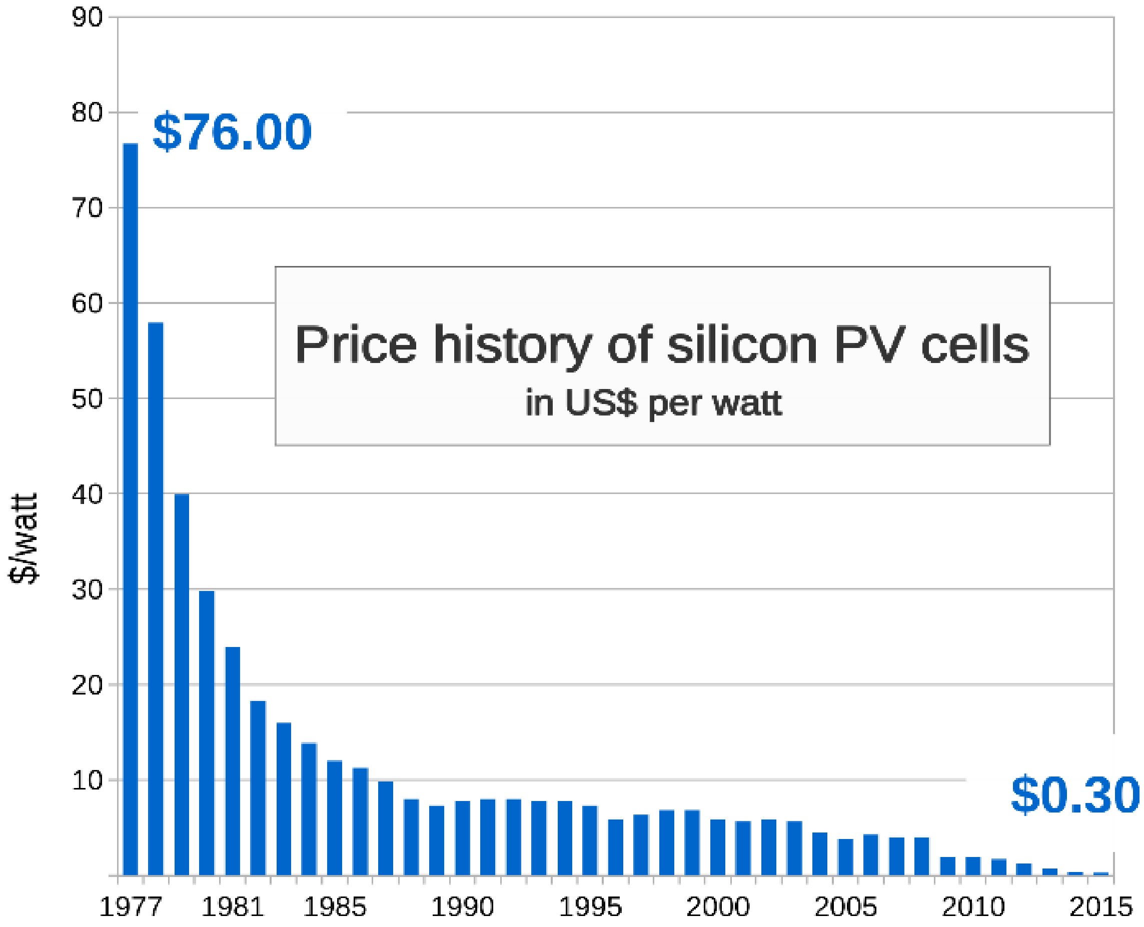


Figure 6: Price history of silicon PV cells (Energy Trend, 2015)

As shown in Figure 6 since the cost trend of PV has dropped so sharply, it is most likely that the cost of home storage systems will also drop accordingly due to economies of scale (Sullivan, 2003). According to Valtteri Kaartemo, this is evident from several large factories set up to satisfy the demand for storage systems in the US and Europe.

3.3 Organic vs. Non-Organic Growth

Historically, the fossil-fuel and nuclear industries have enjoyed massive state subsidies, even after many decades of industry maturity (Mendonca, 2009). As governments around the world now shift their focus to renewable rather than fossil or nuclear electricity production, there is strong resistance from old energy industries to avoid losing their subsidies. This has resulted in passing unnecessarily generous Feed-in-Tariffs to help renewable energy producers without removing fossil-fuel subsidies (IMF, 2015). However, this causes strain on state budgets as they are now subsidizing both ends of the energy spectrum (fossil-based and renewables). Hence some countries such as Spain and the United Kingdom, have rolled-back Feed-in-Tariff legislation or retroactively taxed beneficiaries, effectively penalizing renewable energy pioneers who helped create the first wave of sustainable energy diversification. This indicates that government subsidies can help kickstart an industry but this approach is not sustainable in the long term as it creates unnecessary strain on state budgets according to Juha Saarinen.

This is where organic growth by means of self-consumption of electricity and achieving grid-independence can stabilize the renewable energy sector, as it eliminates the risk of regulatory flip-flops (e.g. when a government passes generous subsidies and then the next government eliminates them) and provides an immediate return to the asset owner from day one (Task Force on Solar Storage, 2016). This may also contribute to lower overall electricity prices once subsidy-inflation has been eliminated.

The challenges with organic growth is that it requires consumer education and participation, which may slow it down, but it may happen once the economic advantages become mainstream knowledge. Secondary challenges also include the technology roadmap of solar storage technologies and whether for example, a shortage of lithium can make home storage systems prohibitively expensive for most consumers.

3.4 Developed vs. Developing Countries

Historically, critics of renewable energy have been highlighting that it is a luxury affordable only by richer more developed countries, but cannot be widely adopted by the developing world. However as Figure 5 shows, 2015 was the first year during which renewable energy investments in the developing world surpassed those of the developed world (FS-UNEP, 2016).

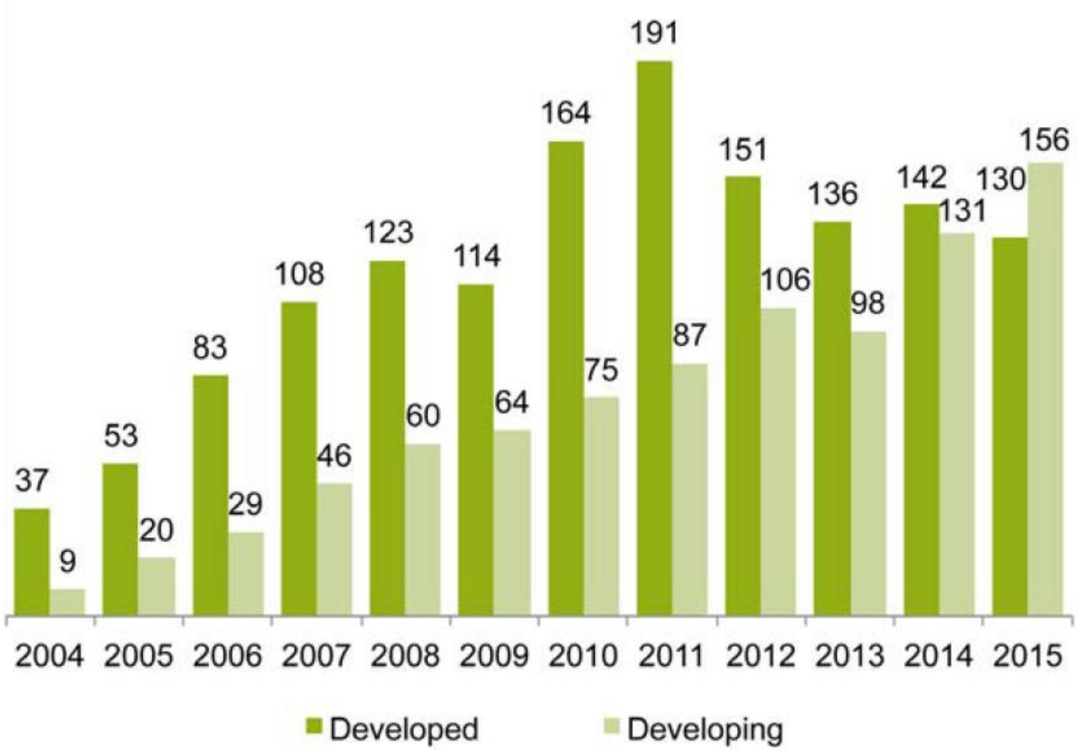


Figure 7: New Investment in Renewable Energy (FS-UNEP, 2016)

Most of the countries on the Global Sun Belt are also developing countries where a solar installation can produce up to 250% more yield compared to a non-GSB regions such as in Northern Europe (Masar, 2016; ClimaTemps, 2016). This is most likely the reason that renewable energy investments by the public and private sectors in the Middle East & Africa (mostly on the GSB) have been up by 58%, almost three times as high as any other region around the world (FS-UNEP, 2016).

This is further reinforced by Sameer Halai, whose platform Sunfunder provides financing for solar projects. Most of the projects on Sunfunder in rural Africa provide a return within less than 5 years, as the end consumers of electricity from these projects currently have no access to electricity or use kerosene/diesel sources on a daily basis which is highly inconvenient, very expensive and harmful to their health and the environment. When their electricity needs are met with solar, they can cut their costs by half, enjoy a reliable and affordable supply while providing a good return to the investors with a relatively short pay-back time.

According to Atter Hanoura, the director of Public Private Partnerships (PPP) at the Egyptian Ministry of Finance, Egypt is set to see a remarkable jump in solar installations during 2016-2017 with the introduction of 4GWp of solar, in a single year. The government has pre-approved over 50 international companies to build utility-scale solar farms of 50MW each with a fixed-PPA of $0.14/KWh which is significantly higher than other countries in the same region such as Jordan (whose price has fallen as low as $0.07/KWh in recent FiT rounds). Such big leaps in year-on-year solar adoption growth has not been seen in most of the developed world which is a clear sign of leapfrogging.

3.5 The Era of Prosumers

In 2016, a Task Force (which Masar is a member of along with Canadian Solar, Enphase, EUROBAT, etc.) was created by SolarPower Europe, the most influential solar industry association in Europe, to submit a report to the European Commission on the recommended regulation of self-consumption of solar electricity with the goal of encouraging or when possible, rewarding self-consumption of generated electricity. If applied, this would signal a major breakthrough for prosumer growth, effectively distributing the burden of asset investment and maintenance over a large group of people (as opposed to currently where it sits squarely on the utility companies). Generally, the developing world follows Europe's policy frameworks so such changes are expected to have wide reaching implications on other global markets as well.

The first entities to implement this breakthrough and build a fully peer-to-peer electricity exchange were battery storage companies such as Sonnen, a German home storage systems company founded in Bavaria in 2010. In 2015, Sonnen Community was launched, allowing members with a charged home battery to sell excess electricity directly to other members. This simplifies the exchange because there is currently no difference between whether the battery was charged from the grid or from a home solar system. Such self-consumption would also allow prosumers to share their excess capacity with one another, without changing the electricity voltage or transmitting it to long distances, thus reducing energy losses.

Furthermore, most prosumers already own or intend to own more than one smart appliance ranging from home automation, energy efficiency systems, home storage or EVs and will therefore, need a centralized system that can manage their production as well as consumption. Sonnen has been successful because consumers might acquire the system to improve their own energy use, but then, passively and easily also improve the energy use of others by optimizing the local grid and selling or buying excess electricity (Sonnen, 2015) If deployed on a widescale, this model completely eliminates the need for a grid and is therefore very suitable for the developing world where many countries do not have good grid coverage.

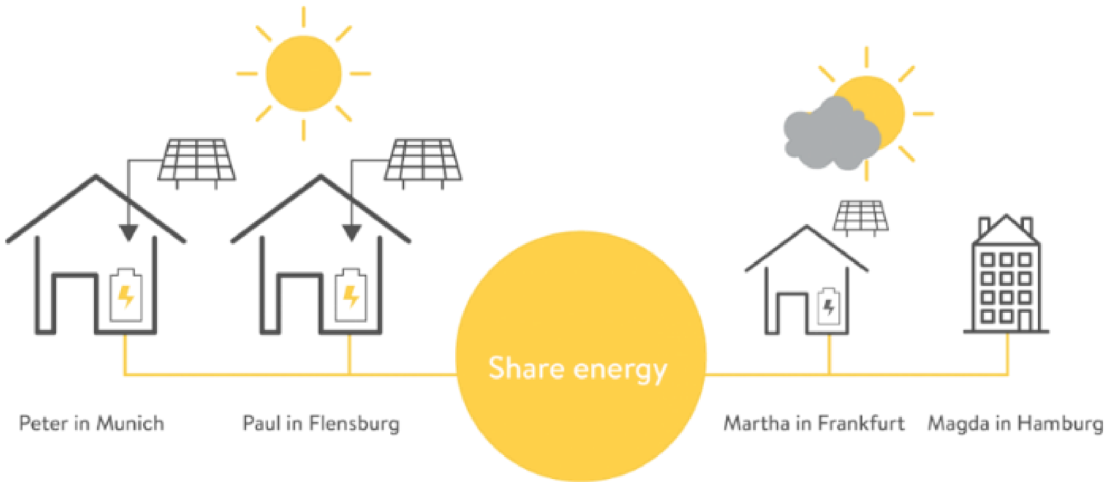


Figure 8: Sonnen allows members to replace utilities (Sonnen, 2015)

According to Sonnen CEO, Boris von Bormann, when they launched their storage product, Sonnen Eco, the plug-and-play prosumer version was their primary flag-ship product as demand in this segment in particular is expected to sky-rocket in the coming years. By exchanging excess electricity with one another, this allows participating prosumers to replace utilities by 100% as shown in Figure 8.

3.6 Home Storage Revolution

> **Global Solar Council Chairman, Bruce Douglas: "Solar and storage are mutually reinforcing. The fast cost decrease of solar systems means that more consumers will be able to invest in storage capacities. This in turn will increase the ratio of self-consumption and brings concrete economic benefits to the consumers. Storage solutions also unlock demand side flexibility which help safely operate our grids."**

One major factor that is likely to catalyse the growth of solar + storage solutions is that consumer battery systems are being produced on a mass scale by companies like Tesla (US-based Gigafactory) & Daimler (Germany-based factory). Other technologies such as Graphene-enhanced or Sodium batteries also promise higher energy density at a fraction of the cost, but they are yet to be available commercially (Graphene Info, 2014).

In countries with dynamic electricity prices such as the Netherlands, where electricity prices change every 15 minutes, this allows consumers to store cheap electricity during the morning off-peak hours, and then consume it or even sell it to the grid during peak hours. The cost of the batteries in the past made the pay-back times too long for this kind of investment, but with the drop in battery prices, this is quickly becoming economically-viable and environmentally-friendly (Task Force on Solar Storage, 2016). This is an additional advantage of using solar + storage technology simultaneously.

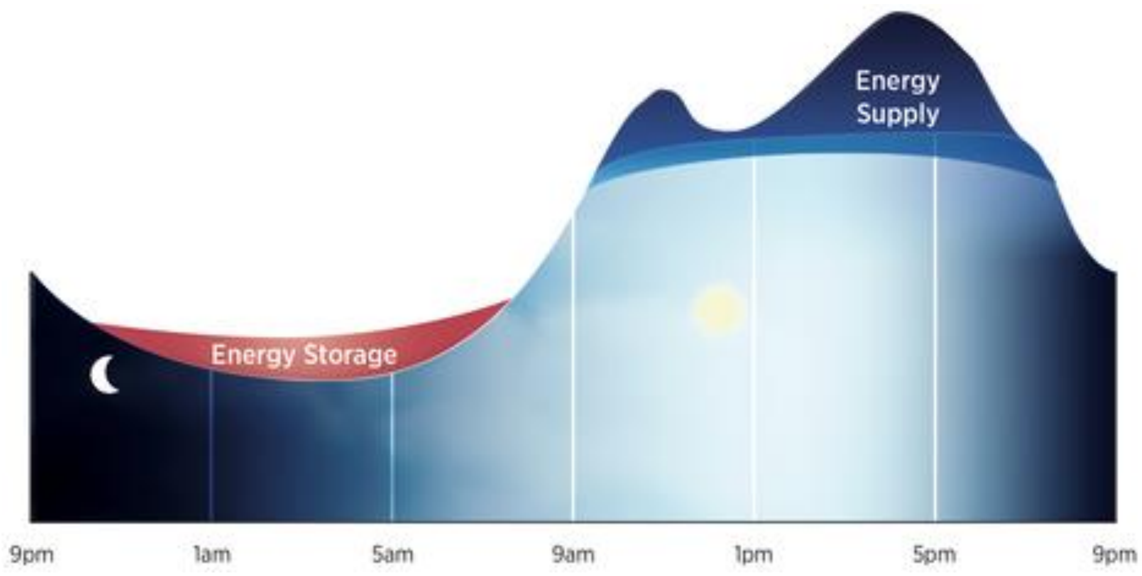


Figure 9: Peak-shaving effect (Open Energy Information, 2016)

When this is done on a massive scale, it is known as “peak-shaving” where the grid ceases to experience huge spikes and valleys in electricity consumption. As seen in Figure 7 and the graph starts to look more uniform, thus resulting in cheaper consumption and a more stable grid.

3.7 The Advent of Third-Party-Ownership

According to Torsten Schreiber, his company Africa GreenTec (AGT) uses Third-Party-Ownership (TPO) model to allows consumers to utilize shipping-container based solar power plants without any up-front investment. For example, German crowdfunding platform Bettervest was used to crowdfund the first system which enabled the company to manufacture, ship and install it in Mali. The system generates revenues from flat-rate fees (€2-3/person/month) paid by every household in the village for the right to consume the solar power, for 10 years.

The company then pays the crowdfunders a steady return on their investment for 10 years. Since the expected lifetime of the container is 20 years, AGT then allows the village to consume the electricity for a marginal cost (€0.2-0.3/person/month) for the following 10 years, after the crowdfunders receive their capital plus interest for the first 10 years. AGT calls this model 7+3+10 i.e. 7 years to return the invested capital with interest, 3 years for AGT to make a margin from the project and 10 years for the villagers to get reliable electricity for a marginal cost. Such innovative models are emerging all around the world and are helping make solar more accessible in the developing and developed world. Similarly, US company SolarCity offers TPO community solar projects that allow a group of homeowners to collectively rent nearby solar power plants even if they don't have the funds to invest upfront or even the roof space for their own installation (SolarCity, 2015).

Similarly, one of the most obvious uses of solar energy is in off-grid solutions and remote areas that usually rely on diesel for electricity. Diesel is both expensive and inconvenient thus making solar power economically-superior in sun-rich regions such as Africa where prices of a diesel KWh can reach \$0.40-\$2.80 (Szabo, 2013) while the price of a solar KWh is between \$0.20-\$0.40 (Masar, 2016).

According to Szabo et. al. (2013), this is primarily due to the cost of operators, who handle transportation of fuel, maintenance and reliability of diesel supply. As most African countries are net importers of fossil-fuels, they must pay for diesel with foreign currency which is often problematic. (Szabo, 2013)

Therefore, solar companies such as Africa GreenTec offer a complete TPO solution which includes access to solar power, storage as well as easy payment options i.e. plug-and-play solution which eliminates the inconvenience of using diesel generators and expensive operators. According to Torsten Schreiber, off-grid solar adoption is the reason Africa is experiencing faster growth than any other region as 600M people still live without any access to electricity, as it includes both off-grid systems and on-grid systems (which are also growing rapidly). (FS-UNEP, 2016)

3.8 Social & Policy Aspects of Solar Adoption

Solar power has gained much acceptance due to its reliability, cost-competitiveness and efficiency, as presented in a number of studies such as Heras-Saizarbitoria et al. (2011), Yuan et al. (2011) and Solangi et al. (2013). This allows Solar adoption to happen also from the bottom-up, simultaneously with large scale projects and top-down policy directives. This is especially evident when several high profile celebrities such as Lionardo Dicaprio regularly address climate change which signals widescale awareness of the issue and its possible solutions to the general public. In 15 years from now, almost half of the power in Europe is expected to be generated by renewables and yet there is no commonly energy policy at the EU level, which slows down the creation of a real European market for solar technology (SolarPower Europe, 2016).

However, after 200 governments signed the Paris Climate Agreement at COP21 in December 2015, there are strong moves to standardize energy policy around the world. For example, the Global Solar Council has been founded during the conference to coordinate the efforts of the world’s solar energy associations and influence a common policy direction among member countries (Masar, 2016). As with any any new industry, there are multiple groups (lobbyists, companies, investors and policy makers) engaging in active discussion on the proper market design. However, there exists strong consensus on fighting climate change, especially due to multiple supporting factors such as technological advances and economic slowdown that make the renewable industry attractive than the more traditional energy industry.

4 THEORETICAL FRAMEWORKS

The premise in centralized power production, is that the government can take a piece of land in a far-away desert and build a single power station supplying electricity to hundreds of thousands or millions of homes. This was possible because the fossil-fuel based source of electricity was very dense and available in large quantities. However, transmission of electricity over large distances and unpredictable supply/demand cycles meant that energy efficiency was low and a lot of the power generated was actually wasted. (Inside Energy, 2015)

According to academic scholar Valtteri Kaartemo, the new renewable energy paradigm theoretically addresses energy efficiency as much as energy production itself. Hence, eliminating such transmission losses provides economically and environmentally superior results to all stakeholders, by maximizing the value of generated electricity and eliminating high infrastructure costs involved with high-voltage long-distance transmission.

4.1 Impact of Solar Adoption on Electricity Prices

According to Desmond et. al (2013), due to falling PV prices and rising electricity rates, it is becoming increasingly attractive for residential consumers to install rooftop PV systems and reduce their electricity purchases from the grid. But as utilities have made capital investments in transmission and distribution infrastructure which they now have to recover from a smaller consumption base, they will have to increase electricity rates. Accordingly, higher electricity rates make it more attractive for consumers to adopt PV and cause utility companies to lose even more revenues, effectively causing a “Downward Spiral” (Task Force on Solar Storage, 2016).

This is why major utilities such as Fortum and investment companies such as Wallstreet Financial Services have announced massive re-focus on renewables so they can bridge the revenue gap with new income from renewable sources, which in some cases consumers are willing to pay a premium for (Fortum, Wallstreet Financial Services, 2016).

As we discussed in chapter 3.2, changes in the electricity prices have an inversely-proportionate effect on consumers and utilities. As utilities experience threats to their business and infrastructure investments, consumers enjoy lower costs of solar installations and accordingly, lower lifetime cost of electricity.

4.2 Decentralized and Peer-to-Peer Solar Power Systems

> **Greeniant CEO, Geert Jan Dirven: "As long as utilities are intermediaries between renewable energy consumers and producers, the market will always be slowed down. The solution is for prosumers to organize directly between one another, thus completely replacing the utilities or relying on them only for back-up."**

According to some researchers, the slowness in adopting solar technologies ultimately boils down to network economics (Jones, 2011) which make the subject both challenging and rewarding. Network economics are business economics that benefit from the network effect i.e.the value of a good or service increases when others buy the same good or service (Shapiro, 1999).

On the one hand, solar power is decentralized and the electricity is consumed nearby where it is produced cutting down the need for expensive transmission infrastructure as well as energy inefficiency. According to the Lawrence Livermore National Laboratory, the US rejects over 60% of its total generated electricity as shown in Figure 10.

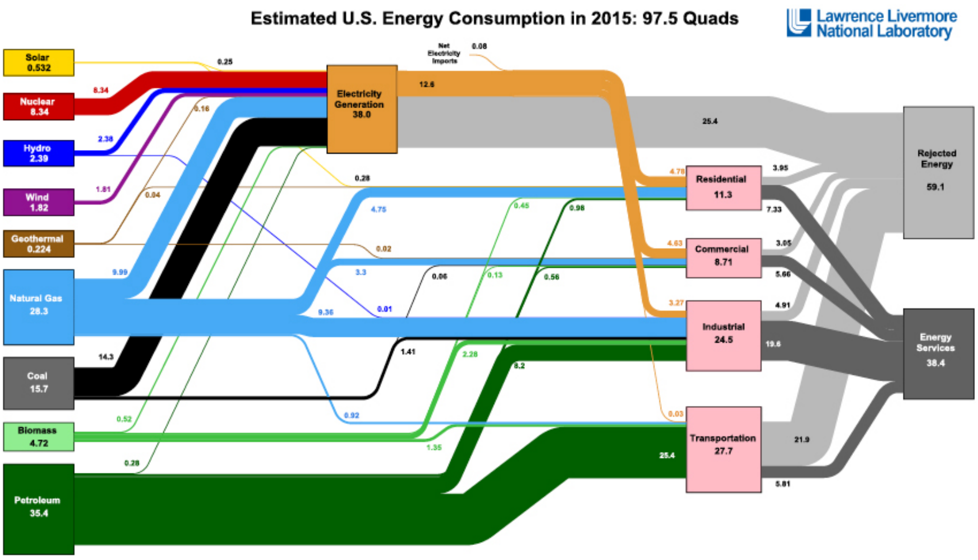


Figure 10: US Energy Consumption (LLNL, 2015)

The increased adoption rate of solar power causes the prices of technology to go down making it affordable to even more consumers (“Halo Effect”) and resulting in a larger and more stable industry that competes on servicing these new installations affordably. On the other hand, it is also more challenging due to the decentralized fashion with which it is installed, requiring the consent and cooperation of thousands of stakeholders (property-owners, local city councils, solar installers, etc.) in order to build a large decentralized network. However, such challenges can be overcome with community solar projects where a group of private homeowners collectively fund the development of a community solar park, or solar leasing programs where the solar developer installs solar systems on private roofs and shares the incentives with the roof owner (Masar, 2016).

According to Robin Chase (2015), utilities should maximize their returns by enabling better innovation, experimentation and resilience to enter the system since power transition to renewable sources is inevitable. By working together with new players including prosumers, utilities can creatively and positively destruct the existing centralized energy paradigms, with newer and more efficient ones (Peers Inc., 2015). Since many parts of the world still have government-owned and operated utilities, this also reduces the fixed costs of the public sector and improves the country’s economic agility (SolarPower Europe, 2015).

4.3 Experience Curves in Solar Manufacturing

Around 20 years ago, Lund University professor Lena Neij used experience curves, an idea developed by the Boston Consulting Group (BCG) in the mid-1960s, to analyse the challenges facing solar manufacturing. Experience curves cause a company's unit cost of manufacturing to fall by about 25% for each doubling of the volume that it produced (The Economist, 1999). At the time, she found solar technology adoption slow primarily due to considerable investments required (Neij, 1997). However since then, as shown in Figure 6 the cost of Photovoltaic (PV) cells has fallen by over 95% (Bloomberg New Energy Finance, 2015) and global deployment has increased 250x (SolarPower Europe, 2015) faster than anyone has predicted (International Energy Agency, 2015). Hence, the world is following an exponential growth curve in solar adoption as our data has shown in Figure 4.

4.4 Challenges Facing Leapfrogging Regions

According to Murphy (2001), these are some challenges facing leapfrogging regions such as Africa which need to be addressed before widescale economic and social progress can be realized. First, technological change is not simply a function of economic supply and demand. Technologies must be tied to the social, cultural, and political institutions shaping rural communities and households. Making these connections is the key to effectively utilizing solar innovation. Second, technological change does not occur in isolation; it happens in sync or sequence with economic development and social change. Lastly, planners must remember that technologies alone do not improve local economies or reduce environmental degradation, people do.

As discussed in chapter 3.1, as solar adoption is driven by multiple segments of society, technological and market dynamics are not the only factors at play. Simultaneously, social and economic development should also utilize solar technology to allow people to narrow their income differences and conserve natural resources. However, if technologies are to be absorbed by rural households in Africa for example, they must be compatible with local limitations. In identifying these limitations, the importance of truly including rural people in energy planning becomes clearer as do the deficiencies in leapfrogging approaches to development. (Murphy, 2001)

4.5 Solar in the Sun Continent

According to Szabo et. al. (2013), the fast growth of solar adoption in Africa, which constitutes the majority of the Global Sun Belt is a result of rapid changes in the market dynamics of diesel (the primary source of electiricty for hundreds of millions of people in Africa). As shown in Figure 10, between 2010-2012 solar had already become more cost-effective than diesel (blue regions indicating diesel more cost-effective have diminished significantly). Such a rapid change in market dynamics is unheard of in more developed parts of the world that have a conventional grid.

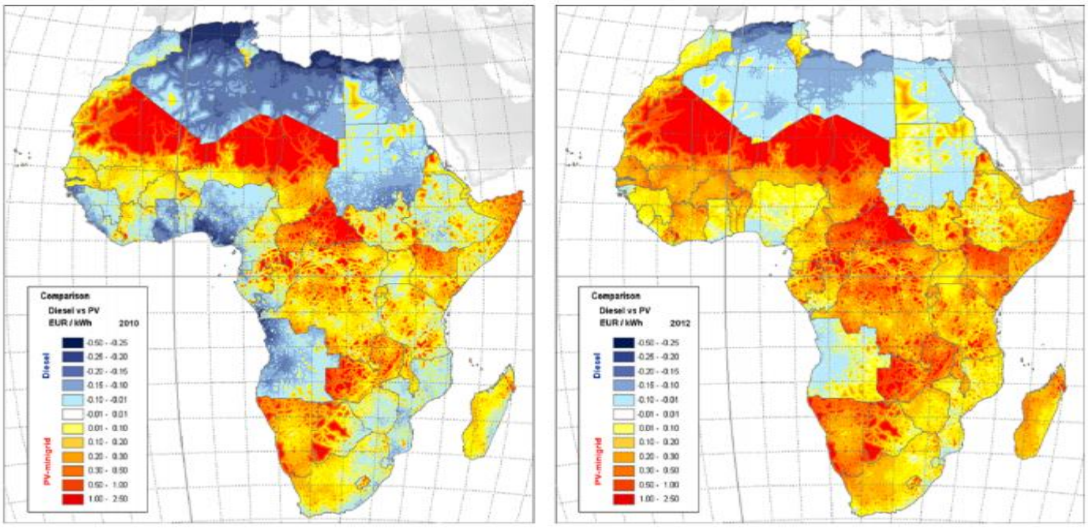


Figure 11: Cost of diesel vs. solar in Africa 2010-2012 (Szabo, 2013)

As discussed in chapter 3.3, such rapid changes in market dynamics enable Africa to outpace every other region and eventually reach similar electrification rates as the rest of the world at a fraction of the infrastructure cost. Furthermore, to further cut down on import costs this could spur an industrial revolution as African countries race each other to manufacture solar modules locally thus creating jobs and reducing their reliance on foreign currency to import fossil-fuels. (SolarPower Europe, 2016) Given these factors, Africa is expected to continue enjoying a faster transition to renewable energy and primarily solar due to its sun-rich climate.

4.6 Institutional Deployment Model

According to Kwok et. al. (2007), while no single effort will dominate in the introduction of renewable energy into the mainstream, governments certainly have a role to play to enable widescale adoption. This echoes the activities of the Task Force on Solar Storage, which addresses necessary public sector action such as standardization of technologies, raising societal awareness of solar potential and improving access to finance, which all work hand-in-hand with incentive programs such as FiTs, net metering or tax-breaks.

A special focus is given to maximizing the value of solar electricity via home storage systems, while ensuring that all dimensions of stored electricity can be properly valued for prosumers. The Task Force also highlights the differences between "behind" and "in front" of the meter storage, covering both technology & cost developments, business models and market information in its guidance.

According to Varun Rai (2016), the two primary barriers of solar adoption for consumers are lack of information and lack of financing. However, we have recently seen an increase in solar awareness globally as well as new financing models such as Third-Party-Ownership (TPO), also known as solar leasing, that allow consumers to benefit from solar without making up-front investements. Another key finding is that consumers who buy solar systems outright have usually previously invested in an EV, smart energy or home storage system thus resulting in a “Halo Effect” caused by the adoption of mutually reinforcing systems (SolarPower Europe, 2016).

Furthermore, the economic slowdown in Europe and low interest rates are driving both private citizens and professional investors to seek growth elsewhere. Given that the market in the developing world, and primarily Middle East & Africa is growing much faster than anywhere else, institutions are also looking at ways to deploy large amounts of capital to benefit from this growth. This of course comes with challenges, as solar developers can easily get overwhelmed with the amount of opportunities ahead of them. In some cases, crowdfunding platforms such as WeShareSolar based in the Netherlands, have announced that there is “too much capital” and “too few projects” on their platform.

5 CONCLUSION

This research aimed to achieve the following objectives:

• To assess which market segments will drive the growth of solar adoption and whether the growth will be primarily driven by market dynamics (such as demand, cost, etc.) or by public policies.

• To assess whether the role convergence between consumers and producers is a pre-requisite to widescale adoption of solar technologies, and what role solar storage will play in the transition.

• To assess whether the developing world, such as Egypt for example, can enjoy a quicker transition roadmap due to the nonexistence of conventional grids and/or the existence dysfunctional grids.

By answering the following questions:

1: What are the interesting trends driving solar adoption and are they policy-driven, technology-driven (such as lower cost) or market-driven?

2: Which trend-setters (including consumer-producers or “prosumers”) are leading the adoption of solar technologies?

3: What are the global regions most likely to experience a breakthrough in the utilization of solar technologies in the next decade?

Driven mostly by on-grid installations, solar adoption has skyrocketed from 2GWp in 2000 to 233GWp in 2015 (SolarPower Europe, 2015; IRENA, 2015). Much of this growth has been policy-driven, however after several countries reversed course on generous incentive plans, a strong trend has emerged towards self-consumption by a new type of player in the energy industry the “prosumer” both consuming and producing electricity at the same time. Assisted by sharply dropping costs of PV and home storage systems (which are mutually reinforcing), prosumers can now create their own electiricity exchange community and share excess capacity with each other in real time, effectively replacing the utility monopoly.

While some have predicted that we are decades away from commercial reality for such innovations, the author expects that this timeframe is most probably too long and that it will not take more than 15 years (i.e. by 2030) for solar power to completely dominate new electricity production, due to the “Halo Effect” of mutually reinforcing technologies between solar and home storage systems.

Furthermore, creative solar financing shemes such as “Third-Party-Ownership” make solar accessible to all sectors of society regardless of whether they can afford an up-front investment into the assets or not. This continues to provide economies of scale advantages to solar adoption driving down the cost of PV and storage.

For example, sun-rich regions in the developing world such as the Middle East & Africa are growing three times faster than any othe region around the world, as they are expected to provide higher returns and shorter pay-back times to investors. Electricity consumers in those regions also enjoy significant benefits from this trend as most of them have not had reliable electricity infrastructure in the past. This enables them to replace costly, inconvenient and environmentally-damaging reliance on fossil-fuels such as diesel. This is equally relevant in both on-grid and off-grid systems which may explain why these regions in particular are experiencing rapid growth in solar adoption as the numbers reflect both segments combined. Hence, the author expects that the Middle East & Africa will most likely exceed its solar deployment targets within 10 years (i.e. by 2025).

Finally, driven by these breakthroughs the developing world has surpassed the developed world in renewable investments for the first time in history which creates a positively reinforcing trend ultimately resulting in lower prices and wider accessibility for solar technologies. This could also be explained due to the economic slowdown and low interest rates in the developing world causing private citizens and professional investors to invest their money elsewhere seeking better returns from a faster growing region. Even private citizens are tapping into these opportunities through crowdfunding platforms that allow them to invest in solar projects internationally which boosts the amount of funds invested towards solar adoption. Accordingly, the author concludes that within 15 years (i.e. by 2030) solar will be a major source of electricity globally.

SOURCE MATERIAL

Agora Energiewende, Europe PV electricity 2015-2050. Copyright © 2015. Online, accessed at: https://www.agora-energiewende.de/en/

Agora Energiewende, Cost of PV in 2050, 4 scenarios. Copyright © 2015. Online, accessed at: https://www.agora-energiewende.de/en/

Alvin Toffler, The Third Wave, Page 11. Copyright © 1980.

Amy Jones, Network Economics: Developing and Implementing Renewable Energy Programs, Page 341 - 358. Copyright © 2011.

Bloomberg New Energy Finance, keynote by Founder Michael Liebreich. Energy Fest 2016.

Bloomberg New Energy Finance, Will the African Development Bank be the greenest? Copyright © 2015. Online, accessed on 15/10/2015 at: https://www.bnef.com/ViewEmail/00a688ca-00d4-cd7a-a718-7b98a2039d68-5a3df12ef9c1-8eed31

Bryman, A. Quantity and Quality in Social Research. London: Unwin Hyman. Copyright © 1988.

Carl Shapiro and Hal R. Varian. Information Rules. Havard Business School. Copyright © 1999.

Carolyn Ellis, Tony E. Adams & Arthur P. Bochner, Autoethnography: An Overview. Volume 12, No. 1, Art. 10 – January 2011. Copyright © 2011.

CIA World Factbook; Electricity Consumption by Country. Public Domain.

ClimaTemps; Sunshine & Daylight Hours in Cairo, Egypt. Copyright © 2009 - 2014. Online, accessed on 07/10/2015 at: http://www.cairo.climatemps.com/sunlight.php

Copi, I. M. et. al. Essentials of Logic (Second edition) Copyright © 2007.

Copi, I. M.; Cohen, C.; Flage, D. E. Essentials of Logic (Second ed.). Upper Saddle River, NJ: Pearson Education. Copyright © 2007.

David L. Green et. al., “Running Out of and into Oil: Analyzing Global Oil Depletion And Transition Through 2050” Page 56, Copyright © 2003.

DEMOS Helsinki, Cleantech Takes over Consumer Markets, Page 17. Copyright © 2015.

Desmond W.H. Cai, Sachin Adlakha, Steven H. Low, Paul De Martini, K. Mani Chandy, Impact of residential PV adoption on Retail Electricity Rates. Copyright © 2013.

Duncan Lablay et. al., “Exploring the Consumer Decision Process in the Adoption of Solar Energy Systems” Copyright © 2014.

Fortum, Remarks by CEO Pekka Lundmark. Copyright © 2015. Online, accessed at: http://www.kauppalehti.fi/uutiset/fortum-lupaa-lisaa-uusiutuvaa-energiaa/P6BD4A6R

Fortune, “In U.S., there are twice as many solar workers as coal miners” Copyright © 2015, Online, accessed at: http://fortune.com/2015/01/16/solar-jobs-report-2014/

Frankfurt School-UNEP Centre/BNEF, Global Trends in Renewable Energy Investment, 2016.

Global Energy Interconnection, Workshop on Technologies and Equipment for Global Energy Interconnection Held in Chicago, US. Copyright © 2015. Online, accessed at: http://www.geidca.com/html/qqnyen/col2015100614/2016-02/01/20160201135343656664740_1.html

Graphene Info, “Is Tesla developing a graphene-enhanced Li-Ion battery?”, Copyright © 2014. Online accessed at: http://www.graphene-info.com/tesla-developing-graphene-enhanced-li-ion-battery

Heras-Saizarbitoria I, Cilleruelo E, Zamanillo I. Public acceptance of renewables and the media: an analysis of the Spanish PV solar experience. Copyright © 2011;15(9):4658–96.

IMF Working Paper, How Large Are Global Energy Subsidies?. Copyright © 2015.

Inside Energy, Copyright © 2015. Online, accessed at: http://insideenergy.org/2015/11/06/lost-in-transmission-how-much-electricity-disappears-between-a-power-plant-and-your-plug/

Institute for Building Efficiency, Feed-In Tariffs: A Brief History. Copyright © 2010. Online, accessed at: http://www.institutebe.com/energy-policy/feed-in-tariffs-history.aspx

International Energy Agency, RE-PROSUMERS 2014. Copyright © 2014.

International Energy Agency, Technology Roadmap: Solar Photovoltaic Energy 2014. Copyright © 2014-2015.

International Energy Agency; Climate Change. Copyright © 2015.

International Energy Agency; Snapshot of Global PV Markets. Copyright © 2014-2015.

International Energy Agency; World Energy Outlook. Copyright © 2015.

James T. Murphy, Making the energy transition in rural East Africa: Is leapfrogging an alternative?. Copyright © 2001.

Kwok L. Shum, Chihiro Watanabe, Photovoltaic deployment strategy in Japan and the USA - an institutional appraisal. Copyright © 2007.

Land Art Generator Initiative; Total Surface Area Required to Fuel the World With Solar. Copyright © 2009-2015. Online accessed on 07/10/2015 at: http://landartgenerator.org/blagi/archives/127

Lena Neij, “Use of experience curves to analyse the prospects for diffusion and adoption of renewable energy technology”. Copyright © 1997.

Leonardo Energy, Burning Burried Sunshire: Human Consumption of Ancient Solar Energy. Copyright © 2015. Online, accessed at: http://www.leonardo-energy.org/blog/burning-buried-sunshine-human-consumption-ancient-solar-energy

Miguel Mendonca, Feed-in Tariffs: Accelerating the Deployment of Renewable Energy, Page 3. Copyright © 2009.

Moody’s; Renewable regulatory risk among EU countries varies; investors in Spain and Italy most exposed. Copyright © 2015. Online, accessed on 07/10/2015 at: https://www.moodys.com/research/Moodys-Renewable-regulatory-risk-among-EU-countries-varies-investors-in--PR_335782

New York Times; American Inventor Uses Egypt's Sun for Power. Copyright © 1916.

Oil-price.net. Copyright © 2015. Online, accessed on 30/10/2015 at: http://www.oil-price.net

Renewable Energy World, Off-grid Solar Applications, Where Grid Parity Is Truly Meaningless, Copyright © 2013. Online, accessed at: http://www.renewableenergyworld.com/articles/2013/08/off-grid-solar-applications-where-grid-parity-is-truly-meaningless.html

Robin Chase, Peers Inc., Page 182. Copyright © 2015.

S. Szabó, K. Bódis, T. Huld, M. Moner-Girona. Sustainable energy planning: Leapfrogging the energy poverty gap in Africa. Copyright © 2013.

Saunders et. al., Research Methods for Business Students. Copyright © 2000.

Saunders, M., Lewis, P. & Thornhill, A. Research Methods for Business Students. Fifth Edition. England: Pearson Education Limited. Copyright © 2009.

Solangi KH, Badaruddin A, Kazi SN, Lwin TNW, Aman MM. Public acceptance of solar energy: The case of Peninsular Malaysia. Page 540-54. Copyright © 2013.

Solar Love, India Likely to Add 10.8 GW Solar Power Capacity In 2016-17. Copyright © 2015. Online, accessed at: http://solarlove.org/india-likely-add-10-8-gw-solar-power-capacity-2016-17

SolarCity, SolarCity Introduces its First Community Solar Option for Renters. Copyright © 2015. Online, accessed at: http://www.solarcity.com/newsroom/press/solarcity-introduces-its-first-community-solar-option-renters

SolarPower Europe, EHPA, EUROBAT, Solar & Storage Policy Paper. Copyright © 2016.

SolarPower Europe, Global Solar Market Outlook 2015. Copyright © 2015.

SolarPower Europe, Task Force on Solar Storage, SolarPower & Storage Workstream. Copyright © 2016.

Sonnen, 2015. Online, accessed on 03/04/2016 at: https://www.sonnen-batterie.com/en-us/start amnd at https://microsite.sonnenbatterie.de/en/sonnenCommunity

Spradley, James P. Participant Observation. Orlando, Florida: Harcourt College Publishers. Page 58–62. Copyright © 1998.

Sullivan, Arthur; Steven M. Sheffrin. Economics: Principles in Action. Copyright © 2003.

Swedish Energy Agency; The World's Energy Use, Figure 48. Copyright © 2012-2015.

The Economist, The Experience Curve. Copyright © 2009. Online, accessed at: http://www.economist.com/node/14298944

Regional Center for Strategic Studies; The Middle East Conflict over Natural Gas. Copyright © 2015.

The UN Refugee Agency (UNHCR); Syria Regional Refugee Response. Copyright © 2015. Online, accessed on 07/10/2015 at: http://data.unhcr.org/syrianrefugees/regional.php

The Weather Channel; The First Six Months of 2015 Have Been the Hottest on Record. Copyright © 2015. Online, accessed on 07/10/2015 at: http://www.weather.com/news/climate/news/earth-record-warmest-january-june-2015

TIME; Blackout: 1 Billion Live Without Electric Light. Copyright © 2013-2015.

Various interviews with Juha Saarinen, Torsten Schreiber, Atter Hanoura, Jochem Wermuth, Sameer Halai, Valtteri Kaartemo and WeShareSolar. 2015-2016.

Varun Rai et. al., “Overcoming barriers and uncertainties in the adoption of residential solar PV” Copyright © 2015.

Wallstreet Financial Services, Focus 2016. Copyright © 2016. Online, accessed at: http://www.wallstreet.fi/en/wallstreet-private-equity-investment-focus-2016-expansion-to-renewable-energy/

Yael Parag & Benjamin Sovacool, Electricity market design for the prosumer era, 2016.

Yuan X, Zuo J, Ma C. Social acceptance of solar energy technologies in China –End users' perspective. Energy Policy. Copyright © 2011.


CERTIFICATE
START UP FEST EUROPE
nl EU 2016
ENERGY FEST
26 MAY 2016, SHELL TECHNOLOGY CENTRE AMSTERDAM
MO EL-FATATRY
MASAR
FOUNDER & CEO
LEADING INNOVATORS
2016