UNLOCKING THE SUNBELT POTENTIAL OF PHOTOVOLTAICS

Second edition – October 2010

European Photovoltaic Industry Association

FOREWORD

The European Photovoltaic Industry Association (EPIA) is delighted to present "Unlocking the Sunbelt Potential of Photovoltaics", a study that was carried in 2010 by EPIA with the collaboration of the Strategy Consulting firm A.T. Kearney.

We would like to warmly thank Mr. E. Macias, President of the Alliance for Rural Electrification, who has first established the concept of this important research, as well as A.T. Kearney for the quality of their contribution as well as the complete EPIA team for steering works and delivering this study.

We also thank ASIF, the Spanish PV association and ARE, the Alliance for Rural Electrification who supported the initial phases of this study.

This study is of considerable importance as it highlights, with demonstrated facts and figures, the immense competitive potential of PV in high irradiation countries, where it increasingly constitutes a clean, sustainable and competitive alternative to conventional fuels.

The study furthermore analyses conditions and explores various possible scenarios under which full PV potential of Sunbelt Countries could be unlocked.

With its unique fundamentals, PV is poised to become a mainstream electricity source able to sustainably meet the soaring electricity demand of growing economies in the Sunbelt region and elsewhere in the World

It is now our collective mission to unlock the potential of PV and deliver the promises of a democratic, responsible and sustainable energy future.

A. El Gammal

Secretary General

Authors:

A.T. Kearney: Jochen Hauff, Marnik Verdonck, Harold Derveaux, Laurent Dumarest, Jose Alberich and Jean-Charles Malherbe

EPIA: Adel El Gammal, Paula Llamas and Gaëtan Masson
ARE: Ernesto Macías

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TABLE OF CONTENTS

1

EXECUTIVE SUMMARY

Photovoltaic (PV) development is booming. With more than 7,000 MW added to the global generation base in 2009, the cumulated installed base is now well over 22 GW. Somewhat paradoxically, however, this growth is mainly driven by countries outside the world's Sunbelt; in fact the growth of PV could be accelerated tremendously, if the world's Sunbelt PV potential would be "unlocked".

Doing so would bring enormous benefits to the Sunbelt countries. PV can contribute significantly to cover the dynamically increasing electricity demand of these growing economies by harnessing low-carbon, free and domestic energy sources - thus decreasing dependencies on (imported) fossil fuels, reducing pressures on water use and improving the carbon balance.

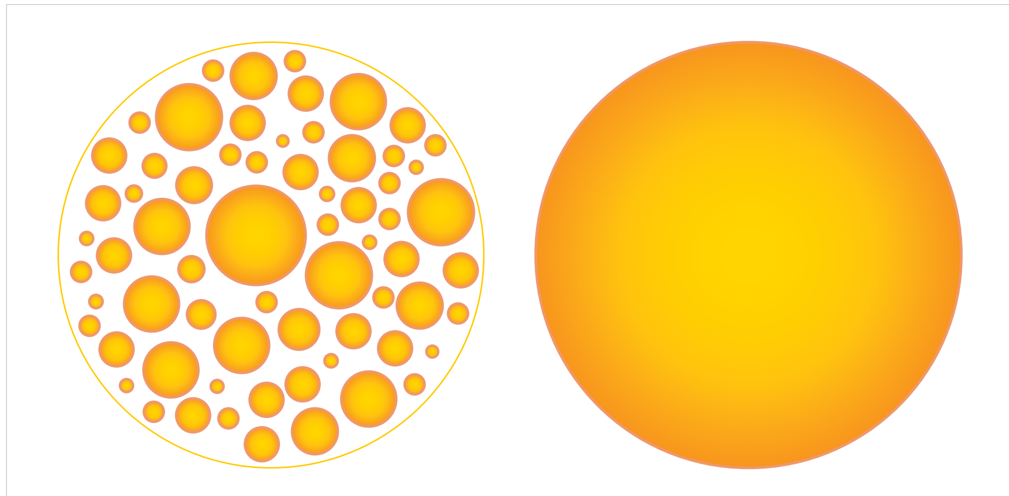


Figure 1 : Sunbelt PV potential

This report presents findings regarding possible scenarios under which the Sunbelt PV potential could be unlocked, namely, the Base, the Accelerated and the Paradigm shift. The study further examines the countries which might be first in line to do so, given the attractiveness of PV for their economies and the overall investment climate they offer. The result is graphically summarised in Figure 1, showing PV potential of 66 Sunbelt countries that jointly constitute one large Sunbelt PV potential. This underlines two main messages : while PV potential differs depending on country size and suitability, there is significant potential in every country of the Sunbelt. And jointly, the PV potential of Sunbelt countries amounts to a major contribution to satisfy power demand and decrease the world's dependency on conventional fuel sources.

Summary findings :

- Under an Accelerated scenario, these countries would reach an installed PV capacity of around 405 GW by 2030, which would provide sustainable electricity supply to about 300 million people and make up between 2.5% and 6% of the Sunbelt's overall power generation.
- Under an ambitious Paradigm Shift scenario, the Sunbelt countries could even reach about 1,100 GW, representing up to 12% of power generation in some geographies by 2030.
- In many regions, PV already constitutes a competitive form of peak power supply. This is true in particular when replacing diesel-fired peak power in distributed generators.
- By 2020, PV can reach LCOE (Levelised Cost of Energy) of 5-12 €cts/kWh in Sunbelt countries. It would then likely be more competitive than gas or oil fuelled peak power plants.
- As cost will drop to 4-8 €cts/KWh by 2030, PV will be competitive with all forms of coal and gas-fired mid-load plants, even if assuming only modest fuel price increases.

Key preconditions :

- To enable realisation of the PV potential put forward in the different scenarios, decision-makers in Sunbelt countries (such as governments and utilities) must consciously include PV as an explicit part of their energy vision and investment planning.
- Power utilities in particular need to utilise the strengths of PV to increase peak capacity and strengthen the resilience of grids by distributed generation assets. At the same time, the opportunity to leapfrog expensive grid development by deploying PV and other renewables must be fully leveraged.
- To facilitate political support, the PV industry needs to increase its commitment to contribute significantly to domestic economic value generation, e.g. by means of investment in manufacturing capacity and establishment of local service offerings. This implies increased levels of collaboration to "open" markets for PV deployment.
- Development banks and private financial intermediaries need to actively address the finance gap that exists in many Sunbelt countries. Transferring experience from established PV markets and collaborating closely with governments and PV industry is key to facilitate project financing.

EPIA's role :

As an active contributor to unlocking the PV potential in the Sunbelt countries, EPIA will :

- Build awareness and know-how in key Sunbelt countries on the benefits of PV as well as on sustainable support policies.
- Facilitate PV industry collaboration on opening key Sunbelt markets.
- Improve the visibility and image of PV with international development banks and agencies with particular focus on grid-connected PV.
- Liaise with financial institutions worldwide to prepare region / country specific financing solutions for PV investment in Sunbelt countries.
- Encourage PV companies and institutions from Sunbelt countries to increase information flow and enable close interaction among sector players.
- Support the strengthening/creation of national PV associations in emerging Sunbelt PV markets.
- Elaborate market development roadmaps for selected Sunbelt countries.

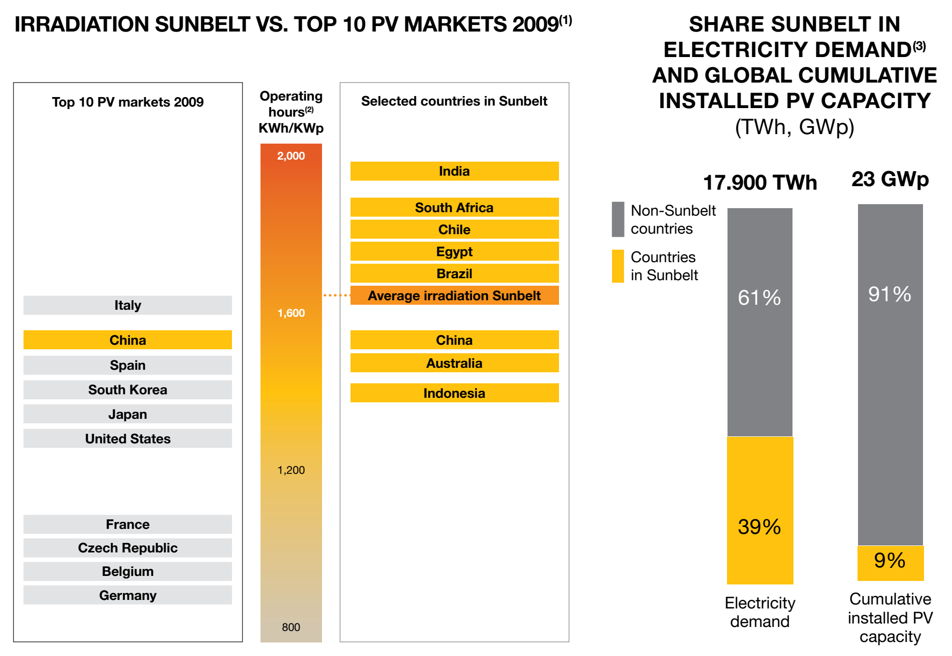
2

THE SUNBELT VISION FOR PV

2.1 The overall Sunbelt PV opportunity

Power generation from PV has reached over 20 TWh in 2009, with over 22 GW of PV capacity installed globally[1]. The tremendous growth over the past years was driven by steep cost and price reductions, as well as significant policy support in a number of key markets. However, it must be noted that the growth occurred primarily in regions of relatively modest solar irradiation : 9 out of the top 10 PV markets are located outside the world's Sunbelt.

This is despite the much higher solar irradiation of Sunbelt countries (Figure 2, left), which make up only 9% of installed capacity today (Figure 2, right). Hence, from a physical point of view, the high solar potential of Sunbelt countries remains largely untapped.



(1) For systems larger than 1 MWp; 85% performance ratio

(2) Cumulative installed capacity 2009

(3) Electricity demand 2007

Source : NASA, IEA Technology Roadmap Solar photovoltaic energy, EPIA Global Market Outlook for Photovoltaics until 2014, A.T. Kearney analysis

Figure 2 : Comparison of solar irradiation, share in electricity demand and cumulative installed PV capacity

At the same time, expected electricity demand growth in the Sunbelt is much higher than in non-sunbelt countries; according to the IEA World Energy Outlook, almost 80% of the expected global electricity demand growth will come from Sunbelt countries[2].

In addition to a contribution to meeting growing electricity demand, PV can provide the solution to many additional energy challenges in Sunbelt countries (Figure 3). These range from a reduction of import dependency, to the contribution to economic and social development resulting from electrification of the country by using highly versatile PV adapted to local needs. Electricity access is a key to poverty alleviation and thus facilitates the achievement of the Millennium Development Goals.[3]

ENERGY CHALLENGES FOR SUNBELT COUNTRIES

- Electricity consumption forecast to grow by ~150% within the next 20 years in Sunbelt countries
- Electricity infrastructure is often poor and 1.5 billion people have no access to electricity which hampers economic and social development
- Many countries have a high dependency on imported fuels for electricity generation
- Large investments in generation and system infrastructure are needed to meet surging electricity demand
- Pressure on Sunbelt countries to increase power generation while keeping CO_2 emissions and other environmental impacts to a minimum

KEY BENEFITS OF PV ADDRESSING THESE CHALLENGES

→ PV taps into unlimited, indigenous energy supply and can make a sizeable contribution to meet rising power demand

→ PV generates power close to consumption, thus supporting strained grids or enabling local mini grids. It can be combined well with other renewable or conventional technologies. PV can thus accelerate electrification and stimulate economic activity, while reducing import reliance

→ High irradiation levels make PV already competitive compared to diesel generators. In the future, PV will be highly competitive to all alternatives. Directing investment into PV now provides a long term source of energy with low operational cost and enables domestic industry build up

→ PV is a low carbon technology and has an "energy packback" time of 10-20 months. It doesn't need water to operate and has no adverse impacts on local air quality

Source : IEA World Energy Outlook; A.T. Kearney analysis

Figure 3 : Benefits of PV for Sunbelt countries

Full realisation of these benefits is currently hampered by a number of barriers that are the reality in many Sunbelt markets. Subsidised fuel prices, limited ability to serve the market and a low level of awareness among power utilities are some of the most important.

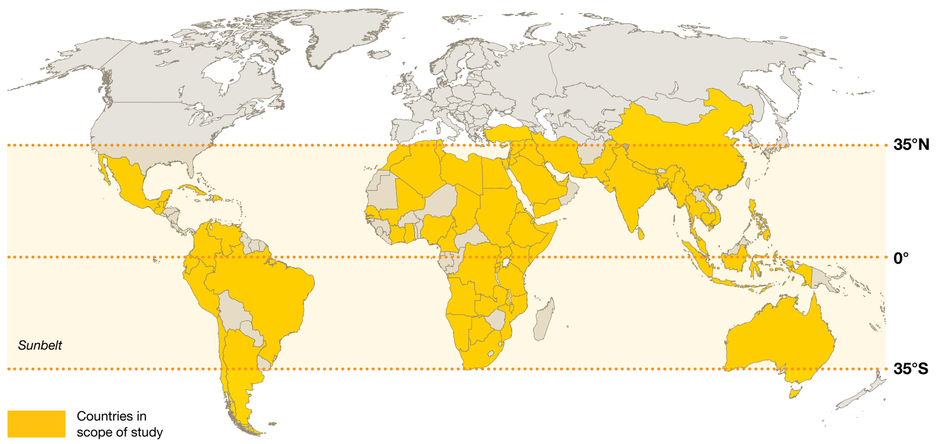
Together, the untapped solar potential, rapidly increasing electricity demand and significant additional PV benefits clearly underline the relevance of this report - Unlocking the PV potential of Sunbelt countries would be very beneficial to all stakeholders.

1 Compare EPIA Photovoltaic Market Outlook until 2014 at www.epia.org

2 IEA World Energy Outlook 2009

3 In September 2000, the United Nations adopted the Millennium Development Goals (MDGs) which range from halving extreme poverty to halting the spread of HIV/AIDS and providing universal primary education, all by the target date of 2015 http://www.undp.org/mdg/

A total of 66 Sunbelt countries[4] are analysed in this report, which are highlighted in Figure 4. These countries with their 5 billion inhabitants represent ~95% of the Sunbelt and ~ 75% of world population. Countries in scope accounted for a GDP of 15.7 trillion USD and consumed roughly 6,800 TWh of electricity, representing 97% of electricity demand of all countries located in the Sunbelt. These 66 countries in scope are referred to when mentioning "Sunbelt" countries.



	Sunbelt countries in scope	All countries in Sunbelt	World
# countries (2008)	66	148	201
Population (2008)	5.0 billion	5.3 billion	6.7 billion
GDP (2008)	15.7 trillion	16.4 trillion	60.0 trillion
Electricity consumption (2007)	6,800 TWh	7,000 TWh	17,900 TWh

Source : World Bank, IMF, A.T. Kearney analysis

Figure 4 : Sunbelt countries in scope of study

The summary result of the PV Opportunity assessment is displayed in Figure 5. Here Sunbelt countries are mapped according to the general country investment attractiveness and the attractiveness of PV for a country. The resulting "PV Opportunity" mapping shows the contribution PV can make to a country combined with the country's likely ability to make use of PV based on its overall investment climate. The PV Opportunity should not be confused with the size of the PV market, although there is a certain correlation as the further discussion will show. This reflects the general thrust of this report, which is not primarily to provide market intelligence to investors in PV, but to point out the contribution PV can make to Sunbelt countries' energy supply as well as providing guidance on how the existing barriers can be overcome.

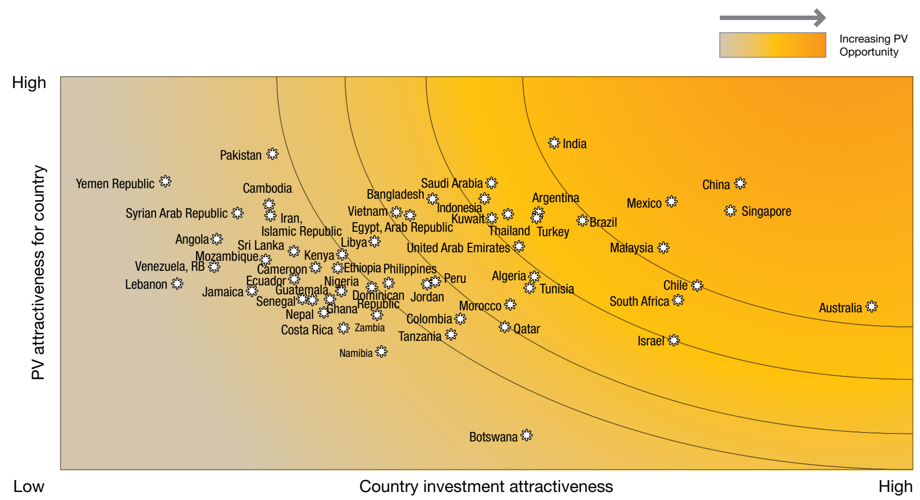
Significance of Sunbelt Countries

The 66 Sunbelt countries analyzed in the study account for 5 billion inhabitants representing respectively 95% of the Sunbelt and 75% of the world's population.

Their 6.800 TWh electricity consumption represents respectively 97% of the Sunbelt and 38% of the world's electricity consumption.

4 Full list included in the Appendix

RESULTS OF THE PV OPPORTUNITY MAPPING (1)



(1) Following countries are not shown on the mapping due to poor availability of data : Chad, Côte d'Ivoire, Congo Dem Rep, Cuba, Iraq, Madagascar, Mali, Myanmar, Somalia, Sudan, Uganda

Source : NASA, IEA Technology Roadmap, EPIA Global Market Outlook for Photovoltaics until 2014, A.T. Kearney analysis

Figure 5 : PV Opportunity mapping of Sunbelt countries

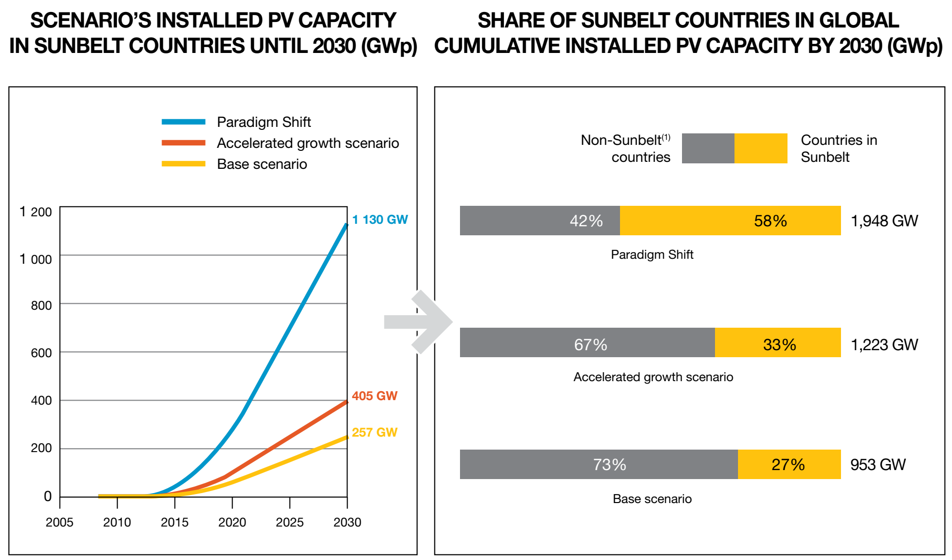
The analysis show a high level of PV attractiveness for many countries along varying degrees of country investment attractiveness. In the top cluster, key countries from various continents such as China, India, Australia and Mexico are included, underlining the global range of the PV Opportunity and representing some of the largest economies in scope. The second and third tiers mostly include a number of "middle" sized countries with dynamically growing economies such as Turkey, Argentina, South Africa, Saudi Arabia, Egypt and Thailand, while the fourth and fifth tiers consist mostly of developing countries like Kenya, Vietnam, the Philippines, as well as countries with higher political risk such as Angola, Yemen and Lebanon.

The following criteria were taken into account to assess country investment attractiveness :
- Overall market potential measured as size of GDP,
- Political and business environment,
- Financial stability,
- Policies on renewable energy.

The attractiveness of PV for a country is largely independent of the country's political and business environment and takes into account the following criteria :
- Size of electricity market,
- Projected electricity consumption growth (2007 – 2030),
- PV cost competitiveness (irradiation, cost of existing energy sources),
- Power distribution / transmission losses,
- Flexibility of current generation mix to accommodate increasing penetration of intermittent electricity sources such as PV,
- Coverage of electricity network (electrification rate).

Data for the clustering has been sourced from primarily public databases from the World Bank, the International Energy Agency and the World Economic Forum. Data usually reflected 2008 status with 2007 used where 2008 data were not available yet. Where necessary, A.T. Kearney supplemented and/or calculated indicators.

Based on the PV Opportunity clustering, Figure 6 presents scenarios of PV potential for Sunbelt countries.



(1) Outlook for non-Sunbelt countries is based on Greenpeace Solar Generation 2010; Base/Accelerate growth scenario is based on respectively the moderate/advanced scenario. Outlook for non-Sunbelt countries in Paradigm shift is the same as used in the Accelerated growth scenario

Source: Greenpeace Solar Generation, IEA Technology Roadmap Solar photovoltaic energy, A.T. Kearney analysis

Figure 6: PV potential scenarios for the Sunbelt

PV Potential in Sunbelt Countries

Depending on the development scenario, PV potential in Sunbelt countries could range from 60 to 250 GWp by 2020, and from 260 to as much as 1.100 GWp by 2030.

Sunbelt countries would then represent 27% to 58% of the forecasted global PV installed capacity by 2030.

Behind these scenarios lies the assumption that the share of PV in a country's electricity consumption is a function of the positioning of a particular country in the PV Opportunity mapping, i.e. is strongly influenced by both the relative attractiveness of PV for a country and a given country's investment climate.

The percentage shares of PV in electricity consumption used as assumptions for the different scenarios were derived from previous studies, showing technical feasibility, such as grid absorption of shares of up to 4-6% and the preconditions for reaching a Paradigm Shift level of up to 12%[5]. The assumptions for the Base and Accelerated scenarios are consistent with the methodology used in the EPIA / Greenpeace "Solar Generation" Studies[6], while the Paradigm Shift scenario is to be seen as a visionary stretch scenario of what would be feasible if a number of stakeholders collaborated closely and decisively to realise the preconditions required to make the Paradigm Shift a reality.

The methodology applied thus represents a top-down approach, applying specific PV electricity share assumptions for each cluster of PV Opportunity as defined above. Please refer to the methodology appendix for details on the exact shares applied.

Due to the high level of uncertainty and fundamental difference of China's development, a different methodology was used to reflect the PV potential for China. It takes into account the somewhat "digital" nature of the Chinese market growth. Hence, the Base and Accelerated scenarios include a relatively low assumption of a 0.7- 1% market share of PV in China by 2020, reaching 2-3% by 2030. This reflects a continuation of the current reluctant approach by the central government's policy makers for some time, followed by an accelerated development between 2020 and 2030 when LCOE are well below current levels. The Paradigm Shift scenario, however, assumes that China will change course soon and decide to unleash the full potential of PV to reach a 4% share in power generation by 2020 and 12% in 2030. Such a Paradigm Shift development would be fully consistent with China's positioning in the PV Opportunity mapping and would make China the dominant PV market in the next 20 years.

Figure 7 breaks down the overall scenario figures for the Paradigm Shift scenario by country. The graph clearly shows the key importance of China for the overall PV potential in the region. This is largely driven by the steep increases in Chinese electricity demand, as forecast by the IEA.

It should be also noted that, when summing up the next 15 "middle" markets, their combined PV potential exceeds that of China under the Base and Accelerated scenarios. Only if the Paradigm Shift scenario came true would China dominate both markets. Hence, PV in the Sunbelt is a multi-country opportunity, offering a broad range of specific countries' potential throughout several continents ready to be unlocked for realising the full Sunbelt potential of PV.

5 EPIA 2009: Set for 2020 Report

6 EPIA, Greenpeace: Solar Generation VI to be released in October 2010.

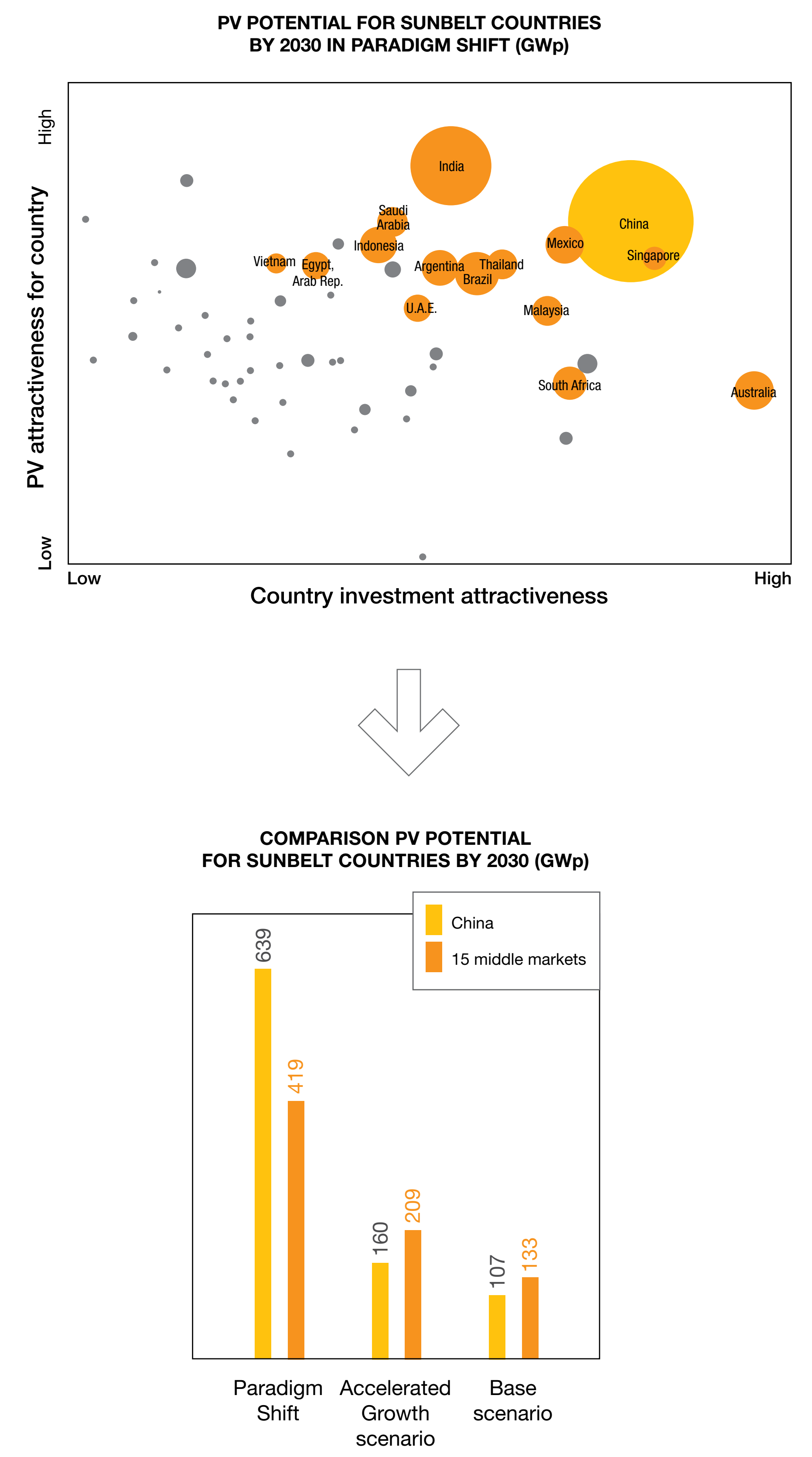
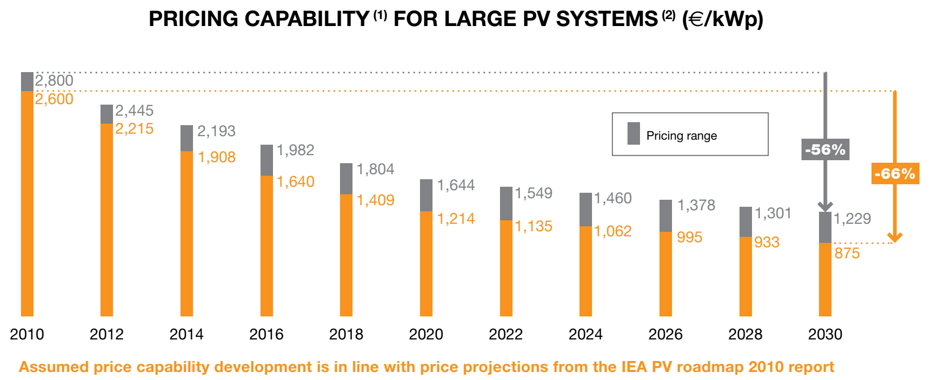


Figure 7 : Comparison of PV potentials for Sunbelt countries

2.2 Competitiveness of PV

A quintessential driver for realising the high potential of PV is, of course, the cost competitiveness of the technology. Among other things, it depends for a given location on the installed prices of PV systems, as well as the expected price developments for conventional sources of power generation.



1) In real terms 2010 €

2) Turnkey PV systems larger than 1 MWp, further details see Appendix.

Sources : NREL, EIA PV technology roadmap 2010, Greenpeace Solar Generation 2008 V, EPIA Set for 2020, IEA Technology Roadmap, A.T. Kearney analysis

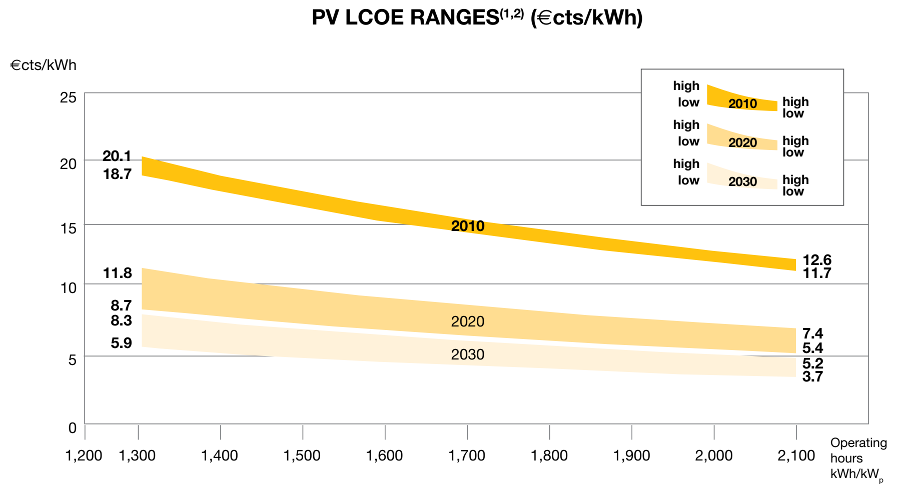
Figure 8 : PV system price digression

In the presented modeling, a price curve for installed PV system prices (depicted in Figure 8) is assumed, which shows a 41-53% digression by 2020 reaching 56-66% by 2030 compared to 2010. This curve refers to large systems of an aggregate of PV technologies commercially available today in the 1 MW class.

The main drivers of the price decrease are technological optimisation and volume effects[7]. The rapid price adjustments which the year 2009 brought are reflected in the price curve published here. Of course, bottleneck situations in any part of the value chain can deflect the development for some regions/years, but the underlying curve is expected to describe a realistic and reliable long term trend.

As a result, the Levelised Cost of Energy (LCOE) of PV for large systems as presented in Figure 9 will be reduced to 5-12€cts/kWh by 2020, reaching even 4-8 €cts/kWh by 2030 in Sunbelt conditions. With current LCOE ranging between 12-20€cts/kWh, PV can today compete with diesel generators for peak power generation without policy support. But, it is still more expensive than the majority of grid-connected power generation capacity. This is the key reason why policy support will still be transitionally needed in many markets for PV to compete during coming years. However, by 2020, PV can be competitive with all peak load electricity generation sources in Sunbelt countries.

7 For more details, please refer to EPIA's Set for 2020 Report



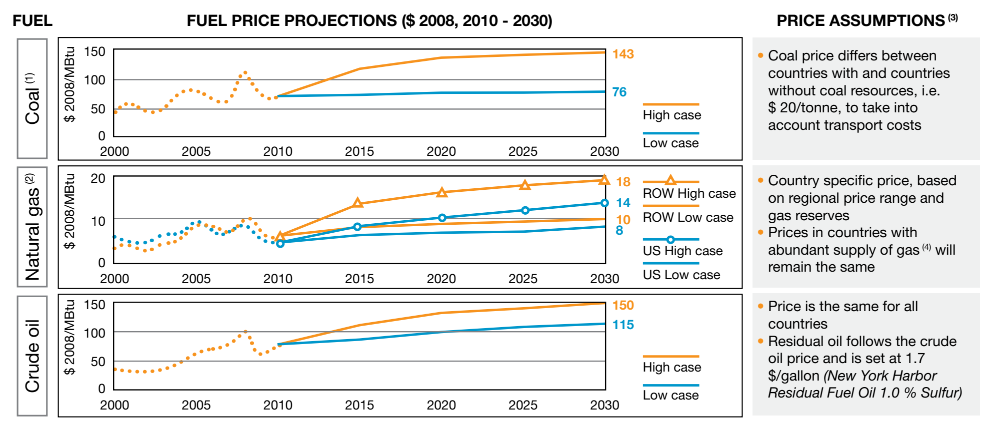
1) Turnkey PV systems larger than 1 MWp, 85% performance ratio; lifetime until and after 2020 is respectively 25 and 30 years; O&M costs 1.5% of Capex; Debt financing with WACC : 6.4 %; System Price 2010 : 2,800 - 2,600 €/kWp

2) Low and high LCOE correspond respectively with the lowest and highest turnkey system price within the price range

Sources : NREL, EIA Technology Roadmap Solar photovoltaic energy, A.T. Kearney analysis

Figure 9 : PV Levelised Cost of Energy in Sunbelt irradiation conditions 2010, 2020 and 2030

On the conventional side, fuel price assumptions are indexed with fuel price projections based on IEA and EIA projections[8]. Country specific natural gas prices were assumed based on regional price ranges, while oil and coal prices were assumed to be global. The effects of current advances in unconventional gas production technology were considered in the gas price projections to the extent possible at the time of writing the report. Figure 10 displays the low and high case conventional fuel price assumptions used in the modeling. The country specific starting points for gas prices as well as assumptions regarding the impact of unconventional gas on the long term development of gas prices are included in the methodology appendix.



(1) OECD Steam coal import price
(2) Historical prices are for the U.S. the Henry Hub price and for ROW (rest of world) the NBP price
(3) See Appendix, for further details on price assumptions
(4) More than 50 years of gas production left, given the current production

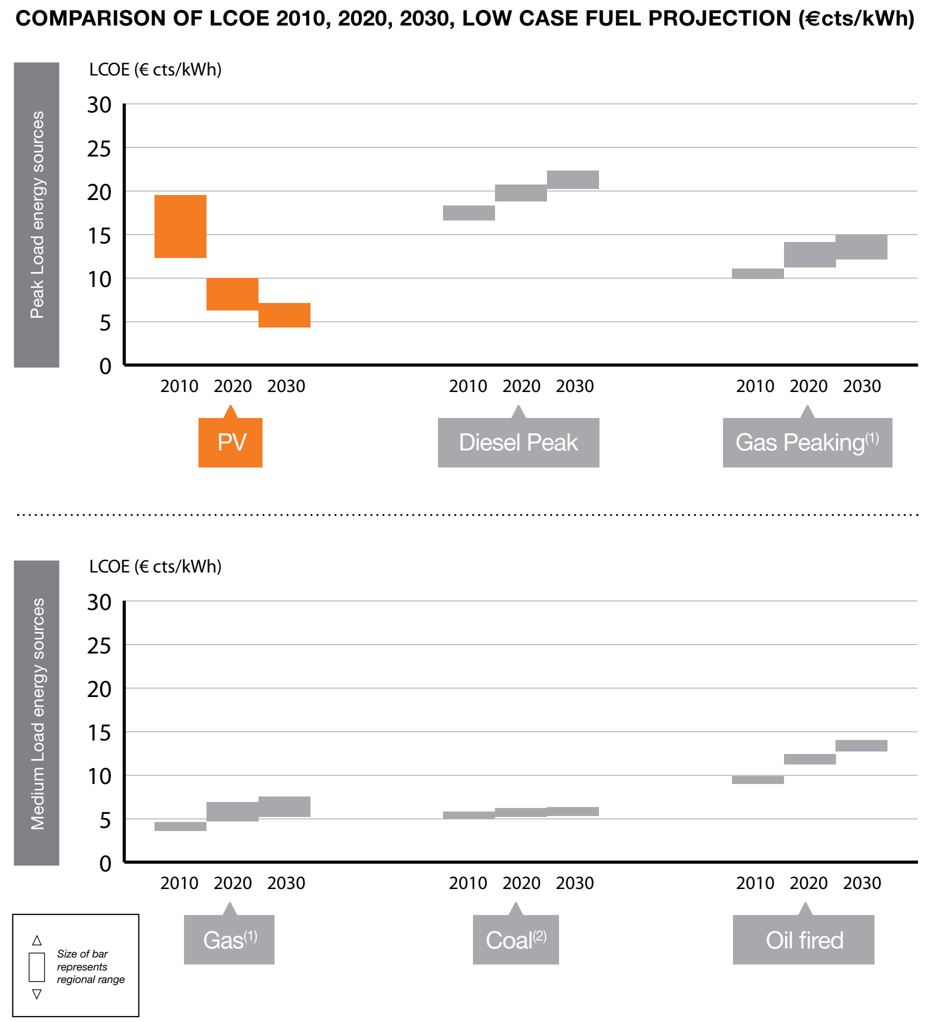
Source : IEA WEO 2009, EIA AEO 2010, BP statistical review 2009

Figure 10 : Fuel price assumptions underlying LCOE comparisons

8 International Energy Agency (IEA) : World Energy Outlook 2009; Energy Information Administration (EIA) : International Energy Outlook 2009

Based on the aforementioned assumptions laid out above, the comparisons of PV competitiveness depicted in Figure 11 and Figure 12 show the following :

- In 2010, PV is already competitive with no additional support if compared to peak power generation from diesel generators, provided their fuel is not subsidised. This already represents a relevant market potential in many Sunbelt countries, where diesel generators are an integral part of power systems,
- By 2020, even in a low fuel price scenario, PV is likely to be more competitive than diesel or gas fuelled peak power capacity. It also outperforms all oil fired mid-load capacities and competes with Combined Cycle Gas Turbines and Integrated Gasification Combined Cycle coal plants for parts of the mid-load market,
- By 2030, also in a low fuel price scenario, PV will be more competitive than all other power generation technologies.



(1) LCOE of Gas Peaking and Combined Cycle Gas Turbine (CCGT) in gas producing countries with very low gas prices are not displayed

(2) IGCC = Integrated Gasification Combined Cycle, a modern coal combustion technology

Source : National Renewable Energy Laboratory, National Energy Technology Laboratory, EPIA Set for 2020, World Bank, A.T. Kearney analysis

Figure 11 : LCOE comparisons PV vs. conventional – low fuel price scenario

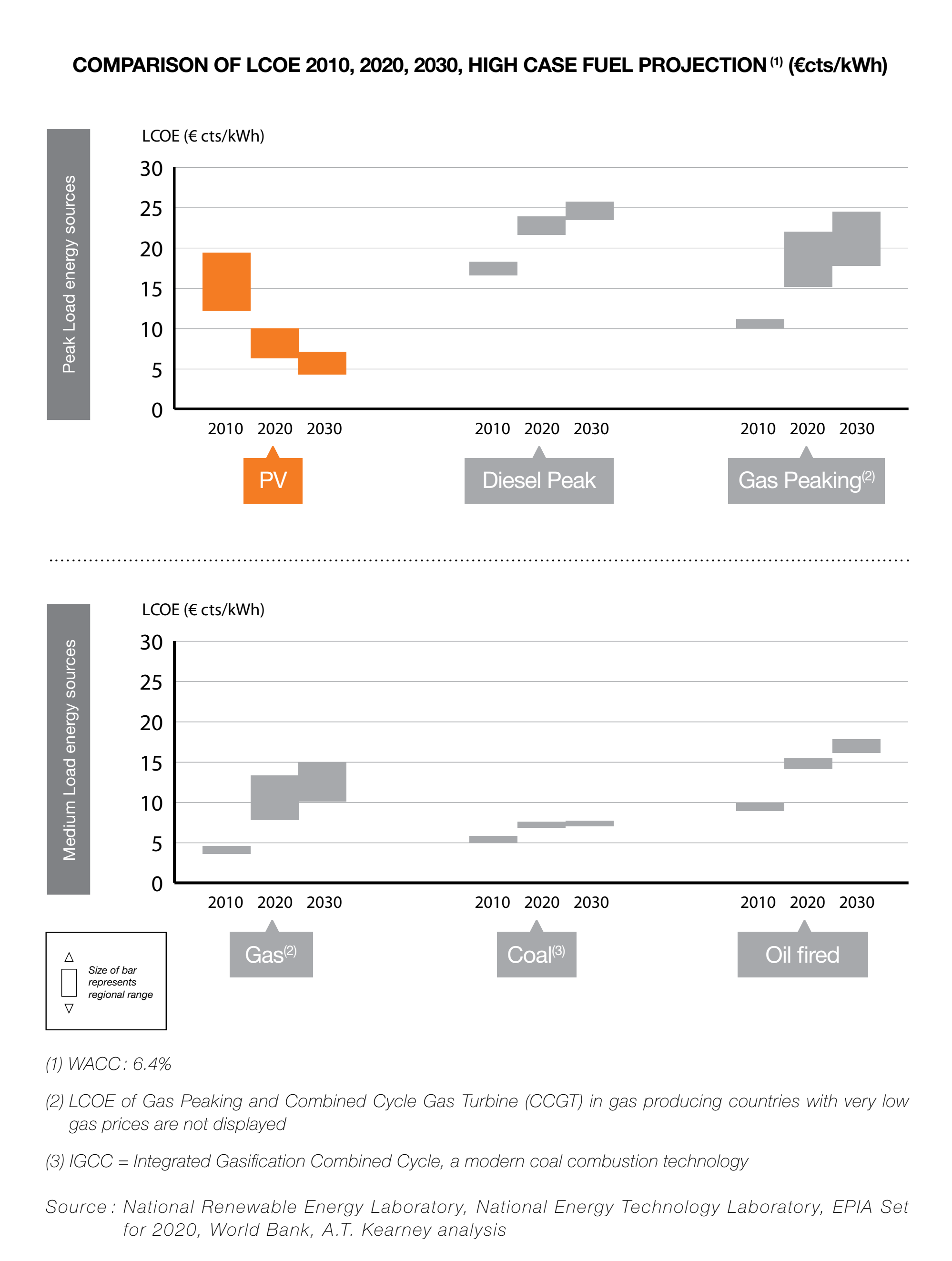


Figure 12: LCOE comparisons PV vs. conventional – high fuel price scenario

Forecasted LCOE of PV in Sunbelt Countries

With expected price digression of 56% to 66% by 2030 compared to 2010, PV LCOE in Sunbelt Countries is expected to range from 5 to 12 €c/kWh by 2020 and 4 to 8 €c/KWh by 2030.

In Sunbelt countries PV is already competitive today with peak diesel generators; it would become competitive with gas fuelled peak power capacity as well as with some mid load capacity by 2020, and would most probably outperform all other power generation technologies by 2030.

Hence, even when assuming low conventional fuel cost, the competitive position of PV is likely to become very strong. In a high fuel price scenario, PV is already competitive against all other power generation technologies by 2020. A significant share of PV as part of Sunbelt countries power generation mix can thus serve as a major hedge for economies to safeguard against strong hikes in fuel-price driven electricity increases. This is an additional essential reason why governments should be highly motivated to support the deployment of PV in their countries already today.

2.3 Key pre-conditions to realise the Sunbelt PV potential

Several barries need to be overcome in order for Sunbelt countries to develop their massive PV potential. This chapter offers a brief overview of key hurdles that stand in the way of PV deployment. It suggests general approaches to overcome them, while a more region-specific view follows in the regional sub-chapters.

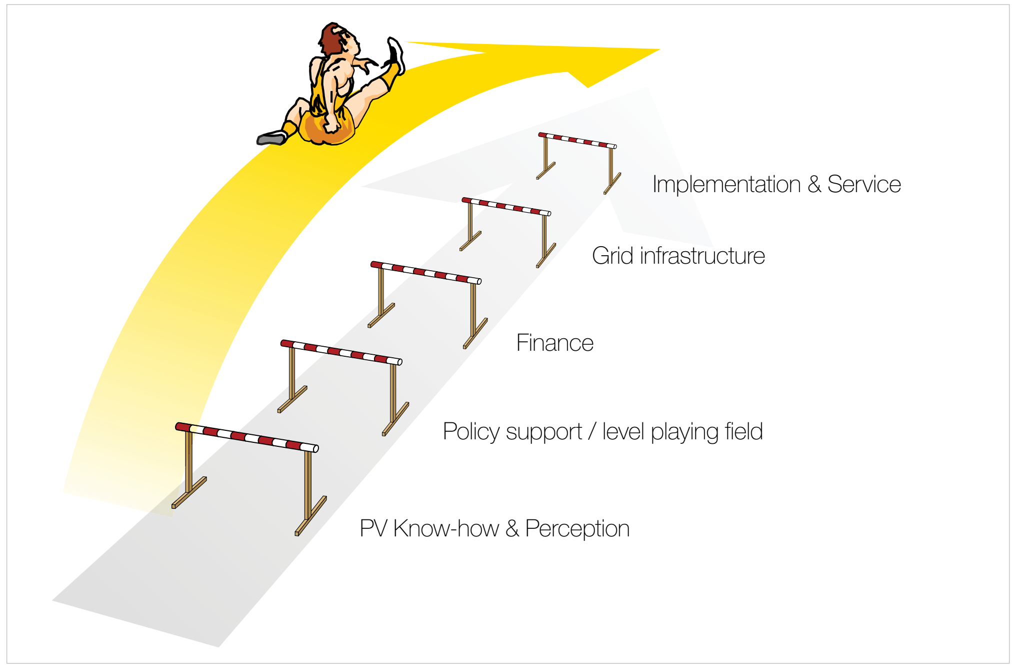


Figure 13: Key barriers to Sunbelt PV deployment

As is depicted in Figure 13, the lack of PV know how is an important hurdle to PV deployment in Sunbelt countries. It prevents PV penetration even where it is already competitive.

Throughout the Sunbelt, PV is still perceived as an expensive energy source mostly suitable for off grid installations of small and medium size. This misconception is not only held among local governments and utility sector players, but also in parts of the development financing community. As a matter of fact, PV can already compete with other commonly used power generation technologies such as diesel generators. Also, PV is still not fully considered by some as a suitable option for large scale power generation. But the truth is that PV is increasingly a competitive large scale alternative compared to other technologies such as Concentrating Solar Power (CSP).

To address such misperceptions, significant awareness building and an information campaign regarding PV are needed among opinion leaders and decision-makers in Sunbelt countries, but also among development banks and other influencers.

In spite of recent improvements in perceptions, the absence or early stage of policy support schemes still represents a significant barrier. This is aggravated by biases against PV such as subsidies for conventional energy use and/or end user electricity prices, which are still widespread. Additionally, administrative hurdles exist due to the novelty of the technology and/or lack of experience at local, regional and national levels.

Hence, highlighting cases of successful implementation is crucial to support the emerging policy initiatives in some countries. In other countries, political lobbying to convince key players of the need for support of PV is essential. Both activities should be informed by policy "experiences" in Europe. While overly generous support schemes in some countries have created overheated markets, others have provided a more stable growth of PV over time. Also, PV support does not have to imply large budgets or cost to the final consumer - simple bottleneck removal such as ensuring grid connection and net metering as well as clear guidance to local and regional administrations for spatial planning and authorisation procedures can help greatly. This is particularly true in countries were PV is already competitive compared to diesel generators. Appropriate and temporary support to close a country's specific competitiveness gap will then ensure accelerated deployment of PV.

Lack of competitively priced finance. While high-profile large projects with political support are currently able to receive finance, the capability/willingness of financial players in Sunbelt countries to finance PV is often limited.

The lack of finance is of course correlated to the lack of PV know-how and early stage of policy support discussed above. To the extent that policy support becomes reliable and word of the benefits of PV spreads, finance can be expected to follow. To accelerate this development, however, financial intermediaries need to be an active part of awareness building. Transferring project finance experience from established PV markets and collaborating with industry and policy experts can turn banks into catalysts for PV deployment rather than constituting a bottleneck. For example, by understanding the functioning of mini-grids in rural communities, banks could also benefit from stimulating economic activity in areas and customer segments that were not the focus of their commercial activity.

Underdeveloped grid infrastructure and inexperienced management limits the absorption of intermittent power sources and increases operative challenges for grid operators.

The lack of grids in some part of the Sunbelt region is an opportunity rather than a barrier to PV. Mini-grids with hybrid systems including PV can fill the gap, leap-frogging the need for a costly grid extension and support economic development by making electricity available swiftly.

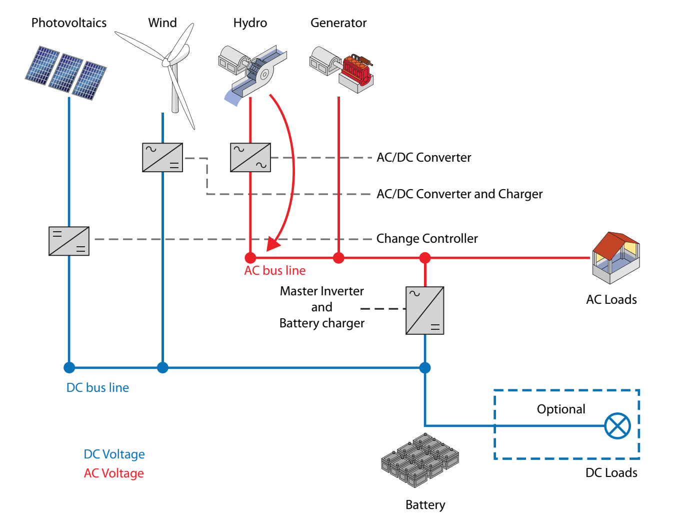
This is discussed in detail in the following special section on mini grids.
In cases where existing grids are regularly facing operative challenges, brown-outs or partial breakdowns, grid-connected distributed PV can be beneficial. For example, in cases of mid-day load peaks, when PV also reaches maximum capacity, the advantage of generation close to consumption can lower the burden on grids. Hence, the key barriers in this context are often grid operators, who are not always aware of these operative possibilities or lack the experience to manage them successfully. In some countries, PV can profit from the pioneering role of wind power deployment. Once grid operators understood how to manage intermittent wind power, they will also be attentive to the benefits of PV, especially where facing mid-day peak demand.

Emerging markets for PV systems and services mean a still limited ability to serve local PV markets, resulting in higher cost and longer lead-times due to a lack of competing offers and long supply chains. This slows PV market development and can put off local investors.

It is here where the PV sector can contribute actively to unlock Sunbelt potential. Market making activities of established PV companies are needed to establish PV firmly and to help create an ecosystem for further growth in a given country. This is already happening in some Sunbelt countries, which also serve as manufacturing hubs, but more countries with significant potential are waiting to be developed.

MINI GRIDS

In countries where a significant part of the population lives in rural areas without link up to a national power grid, mini-grids can provide a solution for supplying electricity at a reasonable cost. Mini-grids can connect a mix of stand-alone electricity sources to private consumers and small business of a community, thus enabling economic activity, education, improved medical care, and increased safety levels. They can be interconnected between communities, forming the nucleus for a more systematic electrification, particularly in more densely populated rural areas.



Source : ARE

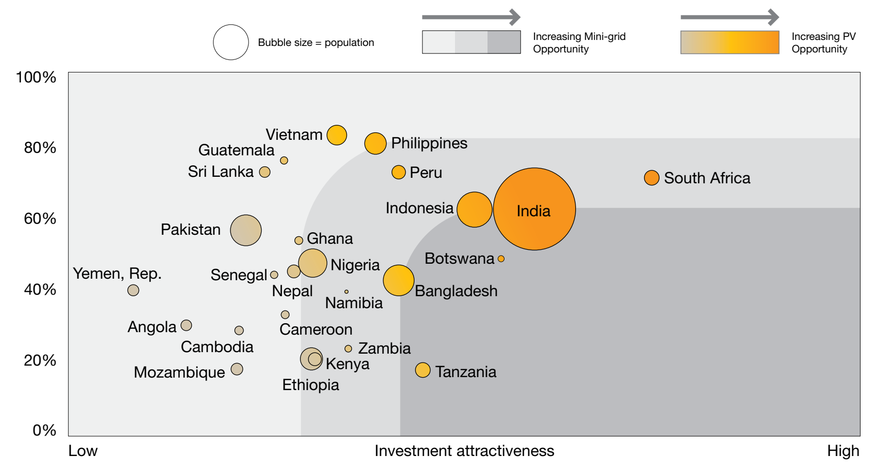
Figure A

Figure A shows an exemplary configuration of a hybrid mini-grid using PV, small wind, small hydro and a backup diesel generator to generate electricity. Batteries can be used as an additional buffer to enhance the dispatchability of the system. Mini-grids have lower and more localized maintenance needs and significantly lower transmission losses compared to long-distance grid extension. Two main indicators determine the size of a countries' mini grid potential:

1) The lower the electrification rate in a country, the larger the potential for mini-grids,

2) The higher the investment attractiveness of a country, the higher the potential for mini-grids.

While the first indicator appears straightforward, the second warrants explanation: investors in a mini-grid need to be reasonably certain of a return. Hence, the investment attractiveness of a country needs to be high enough so that any investor can expect to be paid for their service by local consumers or the community. Such certainty can also be supported by specific schemes where public or donor support covers the difference of an affordable electricity price for communities[9].



Source : A.T. Kearney

Figure B

Figure B shows the mapping of all Sunbelt countries with an electrification rate lower than 90% vs. their respective investment attractiveness. The bubble size represents the countries' total population, while bubble color indicates the size of the PV Opportunity in a given country. Countries such as India, Indonesia, and Bangladesh but also the Philippines and Nigeria show a high opportunity for mini-grids. In those countries alone, more than 710 million people have no access to electricity today. Hybrid mini-grids including PV applications can change this situation at competitive cost and should be actively promoted. "Hybridising" existing conventionally fuelled mini-grids could be a particularly attractive option to increase PV penetration fast. As PV is almost universally suitable in Sunbelt countries, it can be retrofitted to most existing mini grids, thus loweringthe need for diesel fuel and bringing down life-cycle cost of the power supply[10].

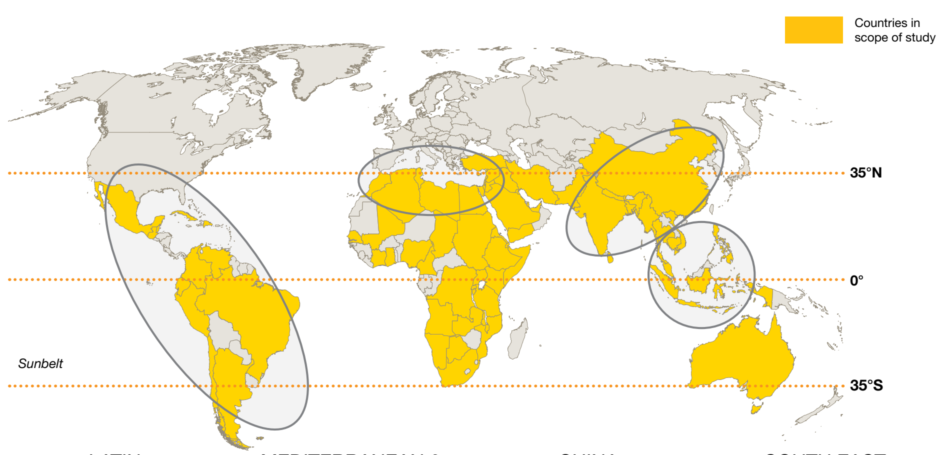
9 JRC – A New Scheme for the Promotion of RE in Developing Countries, 2008
10 Compare ARE Brochure: Hybrid power systems based on renewable energies

3

SELECTED REGIONAL PERSPECTIVES ON PV

Across the Sunbelt, the penetration of installed PV is low. PV manufacturing industry base differs strongly by region, and support policies are only emerging at different speeds. To ensure sufficient comprehensiveness while focus on the most relevant aspects, a selected group of regions within the Sunbelt is discussed in the following chapters. These are highlighted in Figure 14 and represent very different stages of development.

SELECTED FOCUS REGIONS

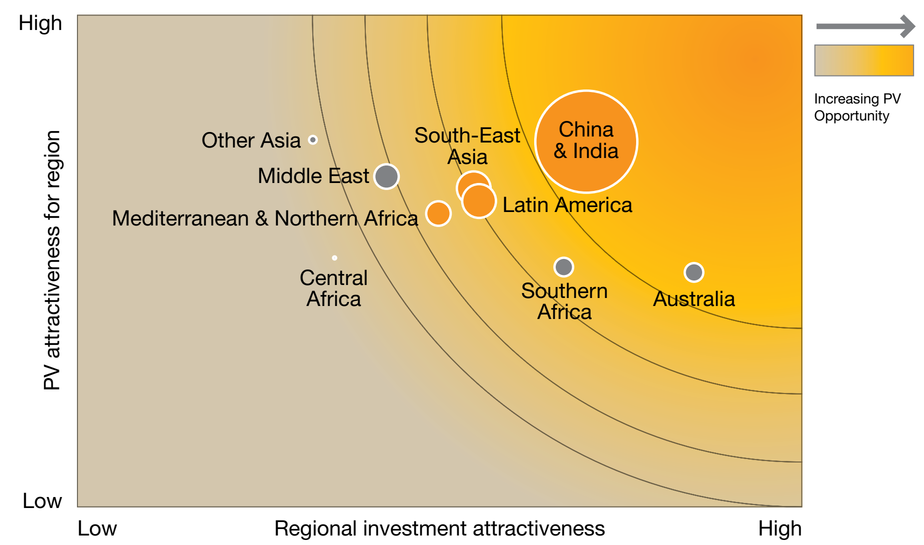


LATIN AMERICA	MEDITERRANEAN & NORTHERN AFRICA	CHINA & INDIA	SOUTH EAST ASIA
• PV potential of 13 GW by 2020 and 48 GW by 2030 in the Accelerated scenario • Current development driven by off-grid applications in remote areas	• PV potential of 7 GW by 2020 and 27 GW by 2030 in the Accelerated scenario • Large scale solar projects are announced; openness for PV increasing	• PV potential of 53 GW by 2020 and 228 GW by 2030 in the Accelerated scenario • Surging electricity demand and existing manufacturing base drive PV potential	• PV potential of 10 GW by 2020 and 46 GW by 2030 in the Accelerated scenario • Existing manufacturing base drives PV growth in the region

Figure 14 : Focus regions of Sunbelt as scope for regional analysis

India & China are both significant players in PV manufacturing in the Sunbelt region, with China dominating by far in terms of capacity, while India has the longer track record. But the installed base is still relatively modest in both countries and policies to spur installation are still under implementation (India) or under discussion (China). **South East Asia** does have some manufacturing capacity and a number of countries are at the verge of implementing promising support policies. Also, a substantial number of projects are in the pipeline and PV growth seems imminent. The same is not true for **Latin America**, where almost no local industry base exists (with the exception of Mexico) and only some countries are contemplating significant support. Here, PV has gained some ground mostly as an off-grid / electrification opportunity, not yet as a part of the mainstream power mix. In the **Mediterranean & Northern African** region, the solar potential is only beginning to be tapped into. PV still needs to be positioned much more strongly in this process which is driven by local policy makers and development banks.

MAPPING OF SUNBELT REGIONS (1)



OVERVIEW OF SELECTED DRIVERS OF PV AND INVESTMENT ATTRACTIVENESS

	Mediterranean & Northern Africa	South-East Asia	China & India	Latin America	South Africa	Central Africa	Australia	Middle East	Other Asia
Electricity cons. (TWh)	463	515	3.682	989	242	44	237	473	110
% of flexible energy sources	69%	57%	4%	33%	<1%	39%	16%	97%	51%
PV LCOE (2) (€/kWh)	0.056	0.059	0.056	0.053	0.048	0.053	0.058	0.052	0.053
PV (3) attractiveness	++	+++	++++	+++	+++	++	++	++++	+++
GDP (bn$)	1,463	1,594	5,486	4,032	285	265	1,015	1,199	297
Approx. Cumul. Inst. Cap. (MW)	43	61	460	73	12	3	104	0.2	20
Country (3) attractiveness	++	+++	++++	+++	+++	++	++++	++	++

Size of the bubble = PV Potential 2030 (Paradigm Shift)

Source: A.T. Kearney analysis

(1) Selected countries as defined in project scope

(2) PV LCOE estimations for 2030

(3) Relative comparison of the researched regions

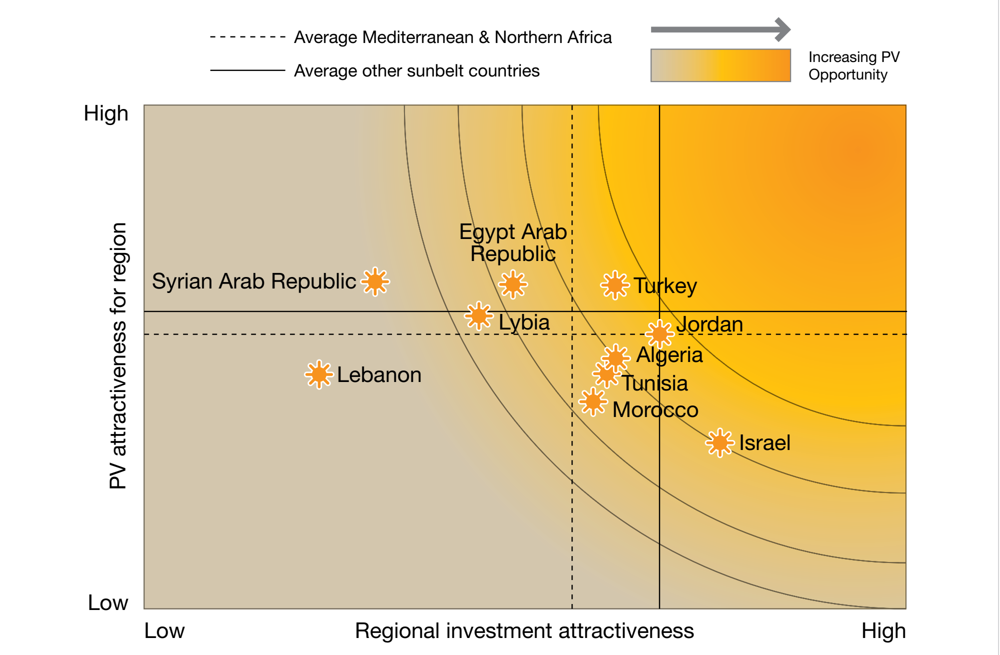
Figure 15 : 2030 Paradigm shift regional potential and key regional indicators

From a PV potential perspective, Figure 15 highlights the significance of the selected focal regions and offers a comparison of some key indicators across all regions. The specific trends opportunities and challenges in focus regions are discussed in more detail in the following sections.

3.1 Mediterranean and Northern Africa

The energy future of non-EU Mediterranean countries as well as Northern Africa currently receives a lot of attention. This is in part due to the high importance of energy for the continued dynamic economic development of countries such as Turkey, Egypt and Morocco, which face significant domestic supply challenges. Partly, however, the attention is also politically driven by the European Union, which intends to increase Mediterranean economic cooperation with programs such as the **Mediterranean Solar Plan**, one of the main initiatives of the Union for the Mediterranean. Also, the industry driven **Desertec Industrial Initiative** (DII) has broadly publicised the idea of an integrated EU / Northern African energy grid with strong solar energy components[11].

Although the region is receiving much attention, it is of medium potential and opportunity when compared to the other Sunbelt regions. With a combined GDP of over $1.5 trillion it accounts for about 9% of Sunbelt GDP and is growing about 3% per annum. While the region accounts for about 6.8% of today's Sunbelt electricity consumption, the identified 30 MW of installed PV represent only around 4.4% of the identified PV capacity in all Sunbelt countries. Figure 16 positions the regional countries in scope vs. the regional and other-sunbelt countries' average.



Source: A.T. Kearney analysis

Figure 16: Med & NA countries PV Opportunity positioning

11 http://www.dii-eumena.com

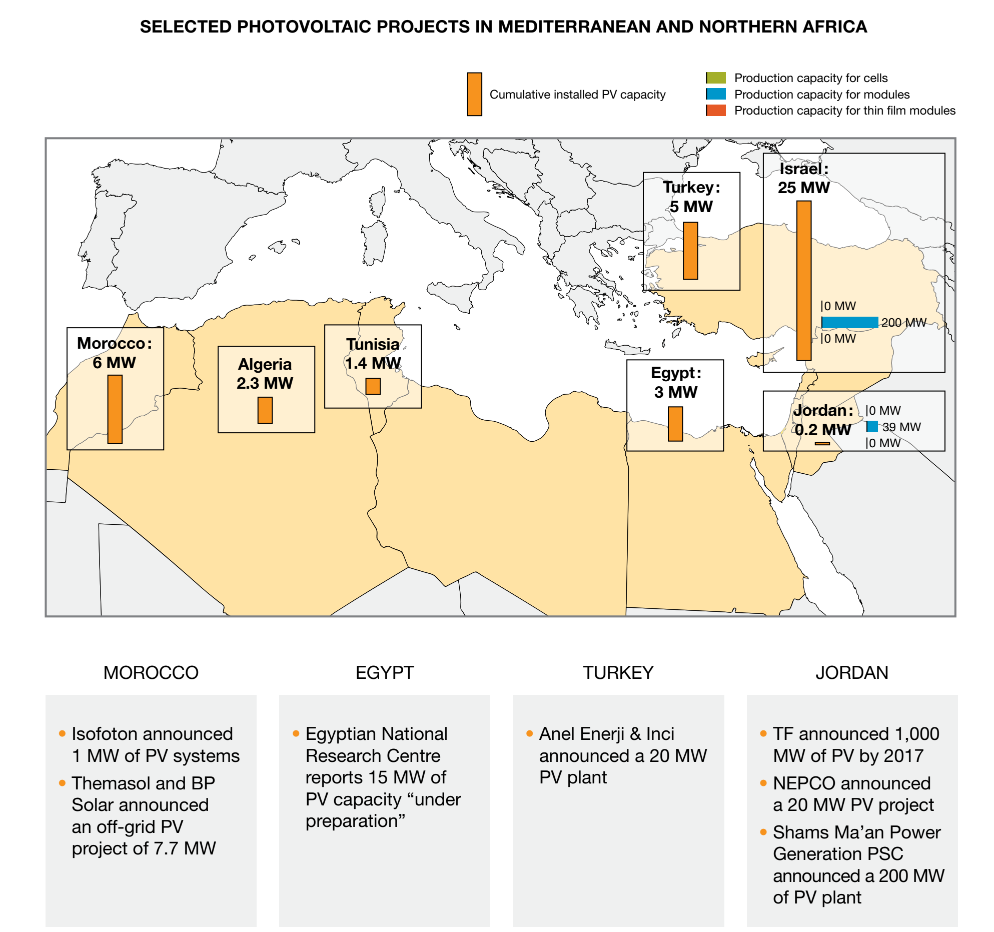
The region's countries show a significant variation of investment competitiveness, mostly driven by political uncertainties in some countries, which reduce the attractiveness somewhat versus an overall relatively stable macroeconomic development. Limited support policies for renewable including PV exist in most countries, except for Libya and Syria where no policy supporting PV is reported. Here, the Mediterranean Solar Plan with its target of 20 GW of renewable energy to be deployed by 2020 in the region could possibly play an important role.

The attractiveness of PV for the countries in the region varies less strongly and is about Sunbelt average for important energy markets such as in Egypt or Turkey, where strongly increasing energy demand is a key driver. A relatively high degree of flexibility in the generation mix with significant shares of oil and gas is a further enabler for PV, while at the same time indicating a comparatively attractive cost position of PV in terms of mid-term LCOE differential.

High electrification rates ranging from 93% to 100% indicate that the off-grid potential of PV is relatively less important if compared to other regions. Significant PV growth in the region would likely focus more on grid-connected installations, which would constitute a departure from the current main application of rural electrification.

Throughout the region, only a modest base of installed PV capacity and PV manufacturing exists to date, but an ambition for larger scale projects exists.

Figure 17 provides an overview of identified capacities and selected sample projects announced.



Source: A.T. Kearney analysis

Figure 17: Med & NA countries installed capacities and example projects

One striking factor in the regional discussion is that many actors on the government and donor side focus very much on Concentrating Solar Power (CSP) applications when talking about Mediterranean and North African solar potential. This reflects partly the fact that there are several CSP investment projects ongoing for some time already, mostly in the form of hybrid applications with gas, e.g. in Morocco, Algeria and Egypt. PV, however, is becoming more present in initiatives such as the Government-sponsored Moroccan project for 2 GW of solar energy which is open for PV as well as CSP. Also, the well known Desertec Initiative is now stressing the fact that it is "technology neutral," i.e. open to both CSP and PV applications. For more information, see the special section about CSP and PV.

Figure 18 presents the regional PV potential for the Mediterranean and Northern African region according to the three scenarios defined in section 2 of this study. The Accelerated scenario suggests an installed PV base of 7 GW by 2020, accelerating growth until 2030 to reach 27 GW. If a Paradigm Shift should occur, a 13 GW potential exists in 2020 and a 2030 installed capacity of 54 GW could be reached.

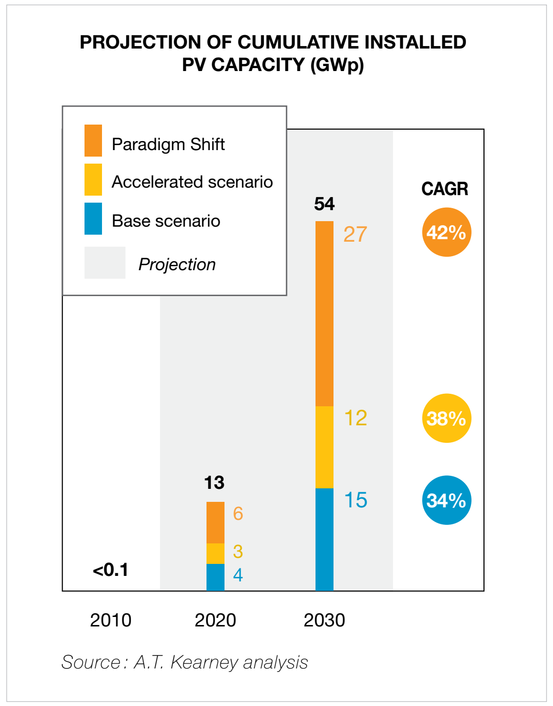


Figure 18: Med & NA countries photovoltaic potential 2020/2030

The key barriers and preconditions identified in chapter 2.3. hold true also in the case of the Mediterranean and Northern Africa. A number of particular preconditions that need to be fulfilled to enable significant penetration of PV in the region are:

- **Know-how and perception** of PV among key government and development bank players needs to change fundamentally. A key example is the multi-donor funded "Clean Technology Fund" which was created in 2008 to provide scaled-up financing for demonstration, deployment and transfer of low-carbon technologies that is administered by the World Bank. While significant loans are earmarked for solar investment, only CSP with trough technology is currently seen as "scalable" and "bankable".

- **Policy support** in the region exists in the form of established renewable energy targets, which countries such as Egypt, Algeria and Morocco have defined. Nevertheless, support mechanisms such as feed-in tariffs are largely lacking with the exception of Israel, where a feed-in tariff for small applications exists. An important draft law has been under discussion in Turkey already for some time, while countries such as Jordan support PV with individual large scale developments. In addition to this wide spread absence of systematic policy support, extensive documentation requirements and bureaucratic hurdles make project development very difficult.

- **Finance** for energy projects is in principle available in the region. But the uncertainties with regard to governments' and utilities' attitudes towards PV, and the lack of formal frameworks of support, make private capital scarce. Key sources of finance for solar projects in the region are development bank loans and grants. Proving the case for large scale PV to development banks will thus be crucial. The Clean Development Mechanism (CDM) as a programmatic financing mechanism is already used for off-grid PV projects in the region and could be rolled out more broadly with the deployment of large scale PV.

- **Grid Infrastructure:** Grid infrastructure in most of the region reaches a high share of population, because, with the notable exception of Turkey, population tends to be highly concentrated in relatively few locations. For example, in Egypt, 95% of the population lives along the Nile, making power distribution a fairly straightforward matter. Bringing ground-based PV to the outskirts of larger agglomerations, or commercial scale systems to industrial rooftops would be a key way to reduce pressures on the grid caused by increasing demand.

  For the relatively low percentage of population outside of the main electrification zones, PV supported mini-grids would enable electrification long before any central infrastructure is likely to reach out to these locations.

- **Implementation and service:** with only a small manufacturing base in Israel and Jordan, there is no well-established supplier base for PV technology and related services in the region. Cultural and political differences as well as limited liberalisation of trade within the region make access to technology cumbersome and costly.

PV AND CSP

Photovoltaic (PV) and Concentrating Solar Power (CSP) represent two distinct solar power generation technologies, which offer a diverse set of characteristics that make each of them suitable for particular conditions and objectives. The table below offers a comparison along a number of key criteria.

		CSP	PV
Installed base end '09 (GW)		0.7	22
Role		Mid-Merit / Peak	Intermittent / Peak
LCOE ($ct/kWh)	'09	19-30	29-33
	'20	11.5-27.5	9.5-12.0
Ease of grid connection		*low* • Often high distance to consumption areas, HV and/or DC links needed	*medium* • Distributed PV simple, large PV plant on ground facilities need MV or HV link
Short term energy on demand		*Possible with thermal storage* • Dispatchable, if thermal storage is part of concept	*not possible / expensive* • Intermittent generation, but high degree of predictability; still expensive storage
Ease of deployment		*difficult* • Specific land / climate conditions required: significant water needs for non-aircooled system • Hybrid solution can lower CAPEX requirement in selected locations • Strong requirement on field topography	*simple* • Simple installation, very fast lead times • No significant water needs • Scalable, can be phased

The distinct properties of PV and CSP make them suitable for different applications that can well complement each other in Sunbelt conditions. While CSP has a role to play, for example, in combination with already established conventional power generation and contributes to dispatchable solar energy in cases where thermal storage is provided, PV's chief role lies in supplying peak power in a broad range of application sizes in close proximity to consumption. Jointly, they can increase the maximal penetration of solar power in many Sunbelt countries. One area of overlap exists regarding larger scale applications in desert conditions. Here, the advantages and disadvantages of the technologies have to be weighed in everyparticular investment case:

In the case of CSP:

- Advantages: Thermal storage option enables dispatching of output; can be combined with existing conventional power plants.
- Disadvantages: Installation location limitations (direct radiation, large, flat ground & significant water requirements). Limited project experiences with the exception of parabolic trough technology.

Regarding PV:

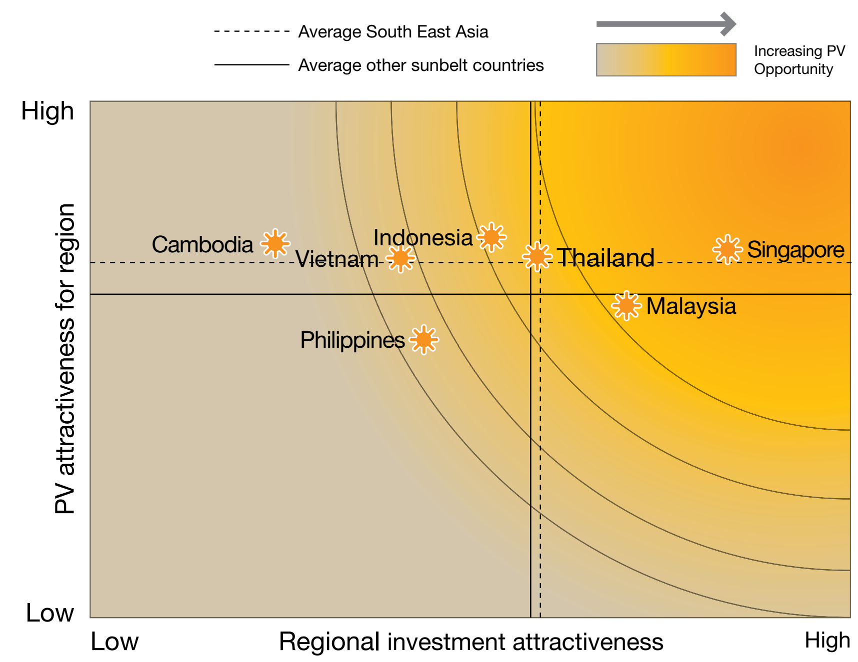
- Advantages: No location limitations, full scalability/modularity of project size, indirect sunlight can be utilised and no significant water needs exist
- Disadvantages: Day production only unless enhanced with (still expensive) battery storage

3.2 South East Asia

South East Asia (SEA) is home to some fast growing economies and an emerging hub for PV manufacturing in Asia. Although political stability deteriorated recently in Thailand, the region at large has enjoyed a stable economic development over the recent past.

The countries in scope (Figure 19) account for a GDP of over $1.5 trillion and make up 9% of Sunbelt GDP - comparable to that of the Mediterranean and North African countries discussed in the previous chapter. However, SEA countries in scope have been growing more dynamically with a strong growth rate of 4.3% in 2008. Also, their installed PV capacity amounts to over 60 MW, which constitutes around 7% of Sunbelt installed PV capacity. This compares to an electricity consumption of 515 TWh or about 7% of Sunbelt final electricity consumption, showing a slightly above average penetration of PV.

The PV growth is mostly driven by Thailand and Malaysia, where comprehensive support policies are emerging. Overall, the PV Opportunity mapping of the region results slightly above the average mapping of the other Sunbelt countries in scope (Figure 19).



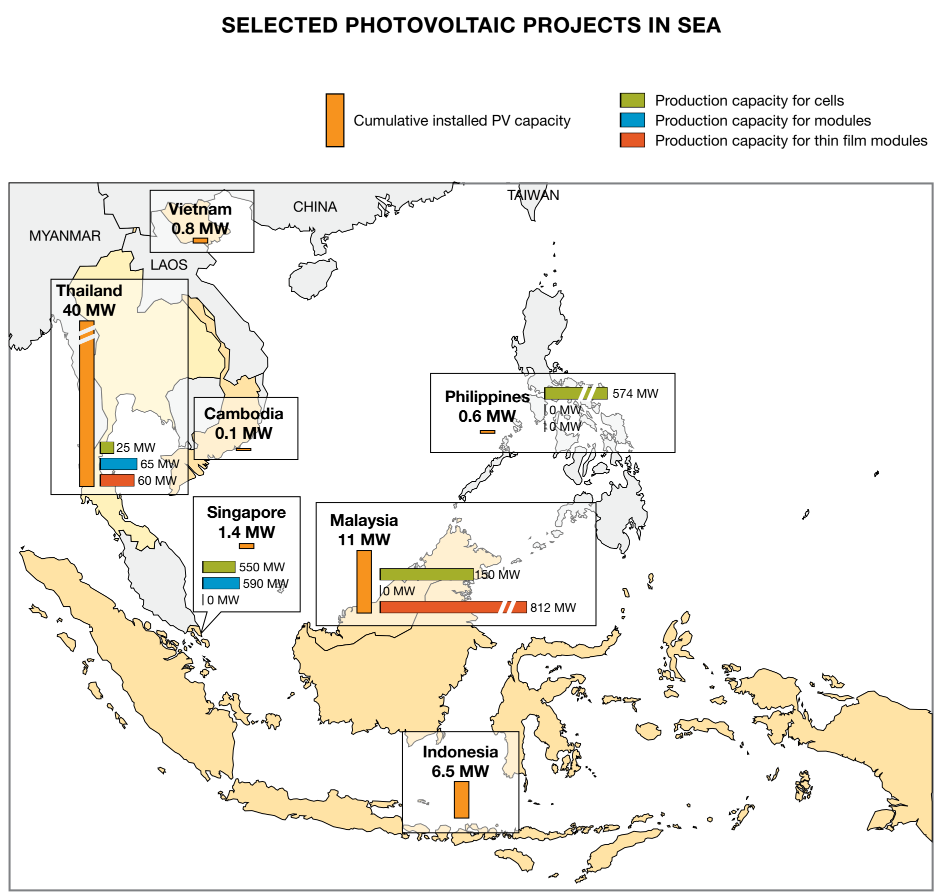
Source: A.T. Kearney analysis

Figure 19: SEA countries PV Opportunity positioning

An important driver of further PV growth is the already competitive cost position in particular in the many isolated systems on SEA islands. PV LCOE in 2010 ranges between 15.5 and 17.6 €cts/kWh in the region, which is already in the competitive range to diesel or gas generated peak power LCOE (9.9 – 18.3 €cts/kWh). Overall, the power generation fuel mix is quite heterogeneous across the region, with Vietnam sourcing only 36% from gas or oil, while the shares of Malaysia and Cambodia reach 64% and 96%, respectively.

Electrification rates in the region range from 65% to 100%, except for Cambodia (24%) where PV can make a particular contribution for rural electrification. Hence, on-grid as well as off-grid PV applications will likely play a significant role in SEA.

A look at the installed PV and PV manufacturing capacities by country (Figure 20) underlines that the region is clearly emerging as a manufacturing hub and that PV deployment appears to be going along with this development. Singapore and Malaysia stick out from a manufacturing perspective with a high output of modules that could satisfy strong increases of regional demand.



THAILAND	VIETNAM	INDONESIA
• IEAGT announced 8 MW of solar power Installations • A Hong Kong based electricity producer announced to build a 55 MW solar power plant • Conergy entered a consortium and announced to build a 3 MW solar plant • Thai Government announced to develop a 73 MW solar field until 2012	• Quang Binh department of Industry and Trade announced to install solar battery systems to generate electricity for daily use in remote communes totaling 790 kW	• Indonesian government announced to extend an existing PV plant with 50 MW

Source: A.T. Kearney analysis

Figure 20: SEA installed capacities and example projects

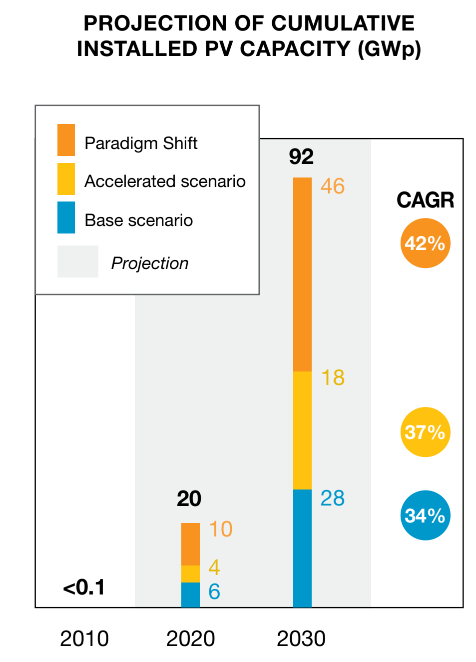
A number of high profile and large scale projects indicate significant increases in installed capacity also in the grid connected arena. Nevertheless, the currently announced projects do not yet represent a stable flow of policy supported investment, but in many cases represent announcements of what could be done if sufficient policy support were available. In that regard, the announcement that Malaysia will introduce a feed-in tariff in 2011 sends a strong signal to its neighbors in the region that PV can make a contribution as a grid-connected source of electricity in addition to the off-grid applications already in use in the region.

Figure 21 presents the regional PV potential for the South East Asia region according to the three scenarios defined in section 2.3 of this study. The Accelerated scenario suggests an installed PV base of 10 GW by 2020, accelerating growth until 2030 to reach 46 GW. If a Paradigm Shift should occur, a 20 GW potential exists in 2020, and a 2030 figure of 92 GW could be reached.

The key barriers and preconditions identified in chapter 2.3. hold true also in the case of South East Asia. A number of specific preconditions to enable significant penetration of PV in the region are:

- **Know-how and perception** of PV or hybrid systems as an opportunity to displace other fuels (for example expensive diesel generation on islands) needs to be enhanced by understanding the grid connected potential of PV as well.

- **Policy support** for PV is emerging or imminent in some markets such as Malaysia, Thailand and Singapore. These should be designed to ensure sustainable support levels based on competitive installed system prices. Currently reported FiT levels of $0.39 to $0.54 per kWh for 21 years under discussion in Malaysia[12] appear, however, rather on the high side. If successful, sustainable policies might serve as templates also for other SEA countries such as Indonesia and the Philippines, where currently no significant policy plans are reported.



Source: A.T. Kearney analysis

Figure 21: SEA photovoltaic potential 2020 / 2030

- **Finance** still constitutes a key barrier in the region and the economic crisis has worsened the situation. Long term government support as well as utility investment will re-invigorate bank trust in PV projects and enable additional finance from banks.

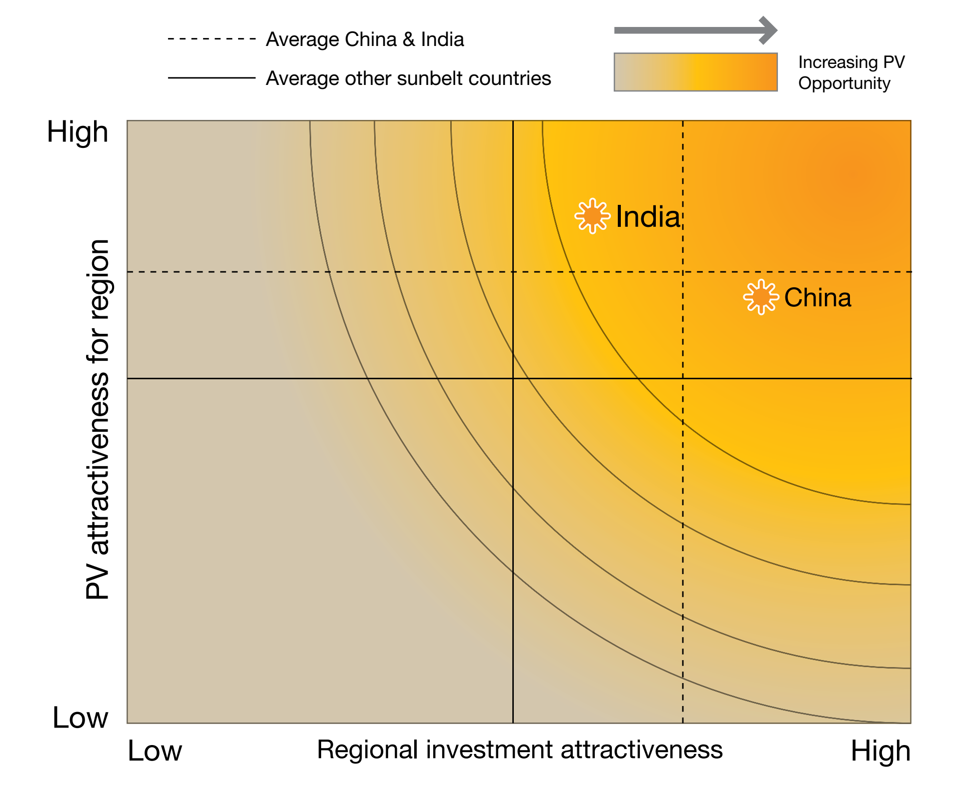
- **Grid** challenges are not likely to occur soon given the low penetration of PV to date. Ensuring effective rules for grid connection is an important precondition for short term development of PV, while realisation of higher PV additions in the mid- to long-term can pose fewer rather than additional challenges in countries with expanding electricity demand and generation capacity.

- **Implementation and Service** - Leveraging the existing footprint of PV industry in the region, it should be possible to improve availability and quality of PV installation and support to final customers. Manufacturers active in the region might do well to consider downstream activities in order to facilitate regional growth rather than focusing exclusively at technology export.

12 http://www.ecoseed.org/en/general-green-news/green-topics/green-policies/feed-in-tariff/7075-Malaysia-finalizes-details-of-feed-in-tariff-for-renewables

3.3 China and India

As the world's most populous countries with steeply increasing electricity demand, China and India play a crucial role for PV in the Sunbelt. While the two countries differ very strongly on many counts, they are treated jointly here due to their large impact for overall PV development in the Sunbelt. As Figure 22 illustrates, China and India are located in the same cluster of highest, with China being better positioned in terms of investment attractiveness, while PV shows a slightly higher attraction for India than for China. If grouped as a "region" their average PV Opportunity rating is significantly higher than that of all other Sunbelt regions in scope.



Source: A.T. Kearney analysis

Figure 22: India & China PV Opportunity positioning

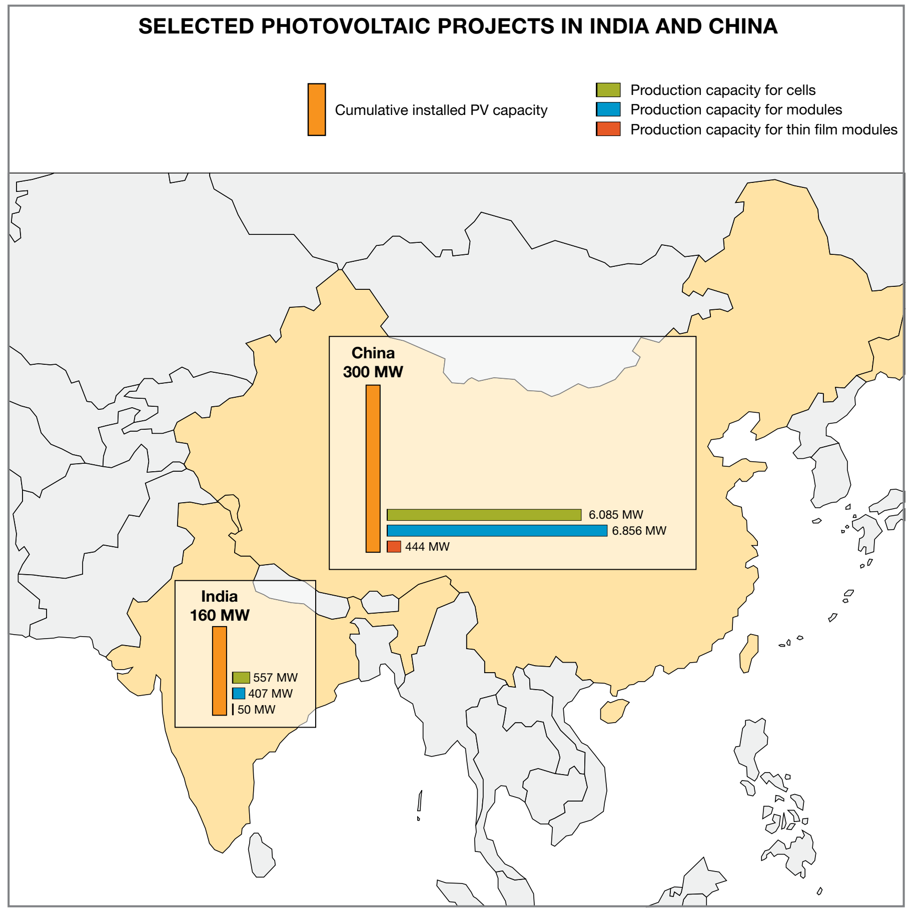
The combined GDP of India and China amounts to over $5.5 trillion and accounts for ~35% of Sunbelt GDP. Gross Domestic Product was growing at a rate of ~8.4% in 2008. In terms of energy, the huge weight of India and China in the Sunbelt region is even more apparent: with an electricity consumption of 3,682 TWh, they accounted for ~54% of Sunbelt final electricity consumption in 2007 (last year for which comparable numbers were available). This significance is reflected in terms of PV - with a combined total of 460 MW, more than 50% of Sunbelt installed PV capacity was installed in India and China. What is more, both countries share dynamic growth rates of electricity consumption and experience supply bottlenecks in catering to the tremendous electricity demand growth.

The discussion in the following section will focus on each country separately before comparing PV potential and barriers to deployment for both countries.

3.3.1 India

Assuming competitively priced installed systems, PV in India can reach LCOE between 12.4 and 13.4 €cts/kWh in 2010. This is well below the range of diesel fuelled peak power (around 16-18 €cts/kWh) but slightly above gas fired peak capacities (10-11 €cts/kWh). PV can thus already make a positive contribution to the fundamental economics of power supply in India where a share of 12% of oil and gas fired capacity is used for peak power supply. Apart from grid connected peak power, PV can also make an important contribution to the electrification in off-grid/mini-grid applications. This is of high economic relevance as only 65% of Indian population is currently connected to an electricity grid.

Due to a comparatively long PV tradition including several mid-sized manufacturing players, India's installed capacity of 130 MW (Figure 23) is significant compared to most Sunbelt countries. This capacity is mostly off-grid capacity in rural regions, which reflects the perception most policy-makers and development banks had of the application of PV.



INDIA

- ZebaSolar announced installation of 10 MW PV capacity in India by the end of 2010
- Astonfield Renewable Resources and Belectric announced to build a 5 MW PV plant
- NTPC announced that it would construct 111 MW of PV capacity by 2014
- Topsun Energy Ltd. announced plans to construct a 5 MW PV system in Gujarat

CHINA

- The Chinese Government selected 294 projects totaling 642 MW to benefit from their Golden Sun subsidy
- Diverse developers announced a total of 12,5 GW of PV projects in China, but deployment will depend on governmental willingness for additional financial support. Examples are:
  - FirstSolar announced plans to build a 2 GW PV plant in Mongolia
  - Suntech announced the extension of a 10 MW utility scale PV plant up to 50 MW by 2011

Figure 23: India & China installed capacities and example projects

In 2009, however, India passed the "Jawaharlal Nehru National Solar Mission", which targets the installation of 22 GW solar power by 2022. 20 GW of this capacity is intended to be grid connected, while 2 GW are slated for off-grid applications.

During a first implementation phase until March 2013, grid connected PV and CSP will be supported up to 500 MW each. Additionally, 200 MW of PV off-grid will be supported. The technology focus for on-grid solar installations during later phases is not explicitly defined, but expected to promote both PV and CSP. The official guidelines stipulate a number of restrictions regarding project size, local content and number of projects per developer, which are to be reviewed regularly[13].

While project acceptance and dissemination of financial support is thus handled on a national level, project preparations will involve a designated agency on the State level, which is to facilitate access to land, water, and the electricity grid. It remains to be see, how quickly States will be able to provide this facilitation and handle the expected high number of project proposals. Apart from potentially slow or overtaxed State level processes, the issue of land use is traditionally difficult in India. Obtaining agricultural or industrial land for PV system installations might impact project lead times significantly. Roof-based systems can avoid this pitfall, but bring their own challenges in an emerging market with a lack of experienced installation players.

Overall, it needs to be stressed that the Indian Government intends to review and adapt policies and technological focus depending on its experience with the scheme. While the initial installation numbers might thus seem small, the establishment of a stable policy process and emergence of well adapted players and technologies can enable a significant scale up after the initial phase.

3.3.2 China

In China, PV can already reach LCOE between 15.3 and 16.5 €cts/kWh in 2010. This is slightly below the range of diesel fuelled peak power (around 16-18 €cts/kWh) but above gas fired peak capacities (10-11 €cts/kWh). As peak power in China is dispatched almost exclusively from hydro facilities owned by grid operators, the generation cost comparison for grid connected PV is not straight forward. While PV can be assumed to free some hydro capacity, which could in turn displace some coal based generation, there is no explicit system peak power cost that would allow for a direct comparison. Hence, on a system level, external benefits of PV would have to enter the equation to make the business case for PV deployment.

Nevertheless, on the commercial end-consumer side, locally differentiated peak prices for power exist, as regional grid operators try to incentivise consumers to decrease demand in peak times. PV could thus play a role for the self consumption of commercial customers trying to shave costly peak usage and/or for regional grid operators which are struggling to balance peak loads only with limited hydro sources. While sizable in absolute terms, the off-grid potential in China appears to be limited to remote areas, while the bulk of electricity demand is in the heavily populated coastal areas, where the penetration of the electrical grid is very high. In these areas, land is scarce/expensive, pointing to a need for roof-based/building integrated development rather than large scale ground- based systems.

13 Guidelines for Selection of New Grid Connected Solar Power Projects. Ministry of New and Renewable Energy, July 25th, 2010

While China commands the largest PV manufacturing capacity in the world, its installed base of PV is insignificant by comparison (Figure 23). PV capacity additions in China have emerged only over recent years under the Golden Sun support system for PV. However, support is capped at 20MW per province and the current overall target is 20 GW by 2020. The Chinese authorities appear currently reluctant to lift the PV caps: as mentioned in Figure 23, a staggering 12.5 GW of PV projects were announced by potential investors by late 2009. Once unleashed, PV growth in China could be explosive. This is perceived by the government to be neither cost effective for the overall electricity bill, nor feasible for absorption in the power grid. Clearly, the huge success of wind power, which has grown over 110% annually in the last four years and has exceeded the official growth target for 2010 by a factor of 5, has made the authorities and energy sector companies cautious regarding triggering a development that might be difficult to manage.

The large manufacturing base is often seen as a reason why China "should" open a domestic market. This is not necessarily obvious to an export-oriented country like China that supplies the world with many products for which it has no significant domestic market. Given that export is currently still going fairly well despite decreasing competitiveness due to the weakening Euro, there is no immediate need for China to trigger domestic demand from an industrial policy point of view. In fact, Chinese officials have stated that there is overcapacity in PV manufacturing. They might thus not deem it necessary to rescue all domestic producers, even if exports should slow.

3.3.3 China and India Potential

Figure 24 displays the PV combined potential scenarios for India and China. The large difference between the Paradigm Shift and the Accelerated Scenario is striking. This is due to the digital nature of China's expected development. The Accelerated scenario assumes a somewhat muted development in China with PV reaching "only" 160 GW of installed capacity by 2030, i.e. eightfold of the official target of 20 GW for 2020, while India would contribute 68 GW, slightly more than threefold the Solar Mission target for 2021. Jointly the two countries would account for 228 GW or 56% of overall Sunbelt PV potential under the Accelerated scenario.

For the Paradigm shift, however, it is assumed that China would shift gear and develop to the full extent their PV Opportunity. This would result in 640 GW of installed PV, generating a 12% share in power generation by 2030. India would in the same Scenario reach 130 GW installed, meaning the both countries would jointly account for 69% of overall Sunbelt potential.

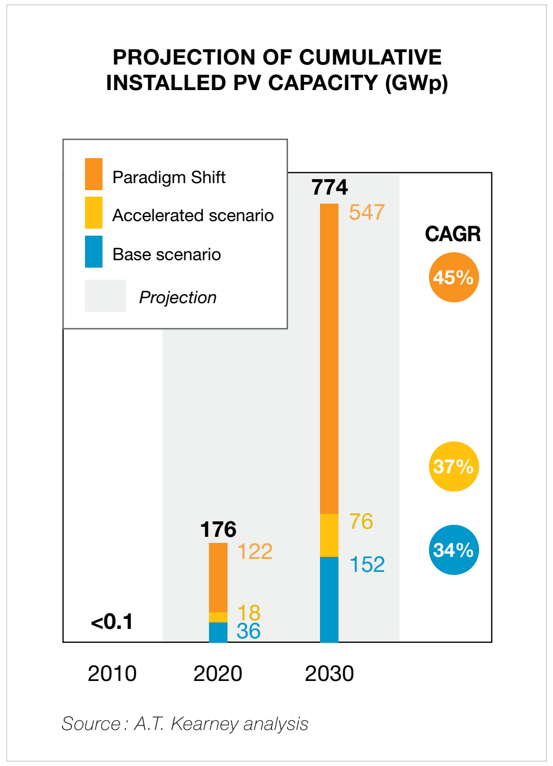


Figure 24: India & China photovoltaic potential 2020 / 2030

Further preconditions that would need to be met along the already introduced categories are listed in the table below

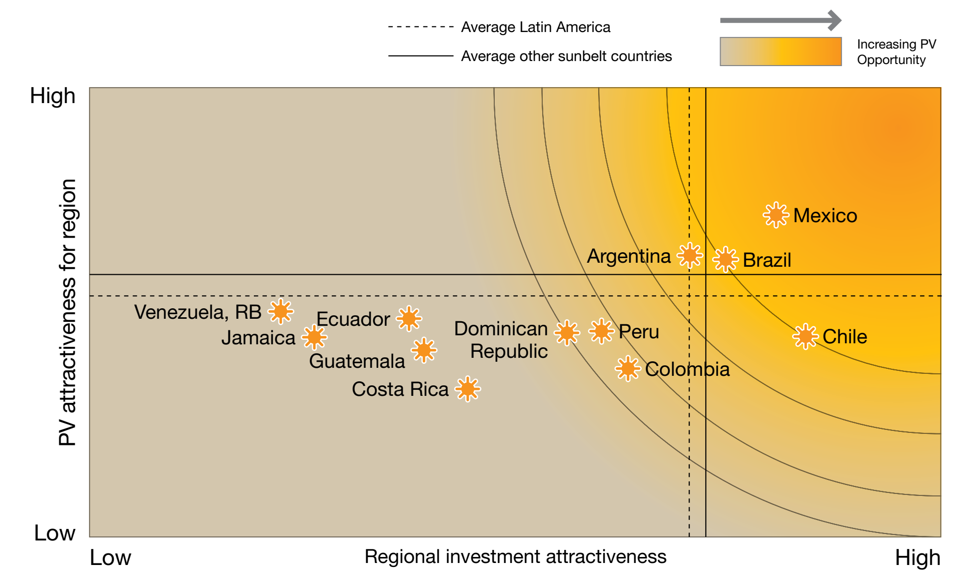
NEEDED ACTIONS / MEASURES

		INDIA	CHINA
PRECONDITIONS	KNOW-HOW / IMPROVED PERCEPTION	Need to increase levels of PV know-how at utility as well as at State / Province level, to enable the rapid implementation of the Solar Mission with a broad range of PV applications.	Need to overcome reluctance to increased shares of PV in central government and energy sector companies. This is usually less of a problem in Provinces that have a significant PV manufacturing base and are keen to develop domestic / regional installer markets as well.
	POLICY SUPPORT	Need to ensure implementation of the Solar Mission on a State level. This should be driven with high priority so that traction is gained soon. Need to anchor PV firmly also as a large scale, grid connected power source while developing the significant off-grid potential as well.	Need to factor in the externalities of fossil fuel use as cost for the “least cost” comparison by Chinese decision makers. This could lead to a re-appraisal of PV as a viable option from an economic point of view to provide the rationale to lift caps of support systems in place.
	FINANCE	Need to define a clearer picture of the actual implementation of support policies in India, which is currently holding up the development of PV plants.	As Finance is available through state owned and private banks it does not constitute a significant bottleneck for commercial investors.
	GRID CHALLENGES	Need to address the lack of an electricity grid in many regions by leveraging PV as an element of hybrid mini-grid systems to leapfrog development patterns and electrification without massive investment in the expansion of the national grid.	Need to address concerns among grid operators regarding the stability of grids when integrating PV. The potentially beneficial nature of PV as a natural balance to wind needs to be examined. Integrated management concepts of a network of renewables need to be tested/introduced. Incentivising PV development in portions in the grid that are in need of peak power and / or are close to demand centers can mitigate the perceived problems significantly.
	IMPLEMENTATION AND SERVICE	Need to build on the domestic manufacturing base to provide a base level of services, while improving industry design and quality standards to channel development activities and increase quality control of end consumer installations.	Need to develop the domestic market to provide an opportunity for PV players producing in China to grow also downstream in the value chain. Many companies are entirely geared for export and focused on manufacturing and have not currently build up significant domestic service capabilities.

3.4 Latin America

Overall, Latin America provides a PV Opportunity close to the overall average of the Sunbelt region. At the same time, the current utilisation of this opportunity is relatively low.

Latin American countries in the scope of this study have a combined GDP of over $4 trillion accounting for 26% of the energy generation capacity installed in the regions researched. This is much larger compared to the GDP of Mediterranean, Northern Africa and South-East Asian countries discussed in previous chapters. Also GDP growth was relatively high in 2008 (4.1%). However, the cumulative PV installed capacity amounts to only 56 MW, being around 4% of Sunbelt installed capacity. Around 95% of this PV base is located in Mexico, Brazil and Argentina, with almost no installed capacity reported in the other countries considered in this region. Comparing this to an electricity consumption of over 1,000 TWh (15% of Sunbelt final electricity consumption), the Latin American region shows a below average penetration of PV compared to the other regions.



Source : A.T. Kearney analysis

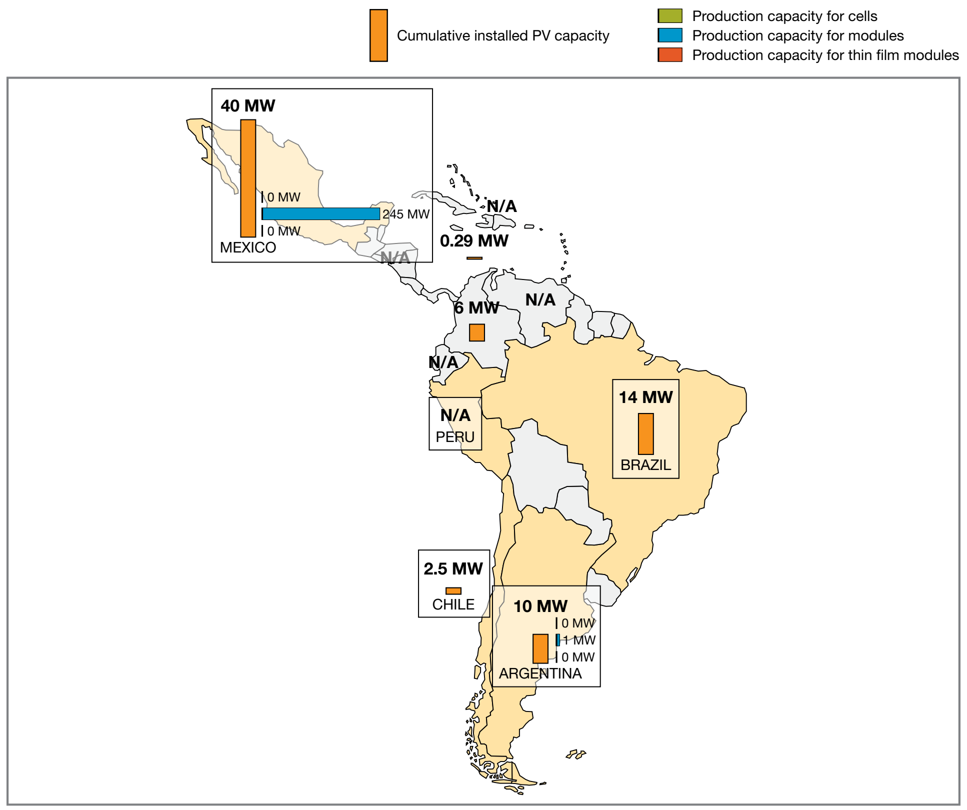
Figure 25 : LA countries PV Opportunity positioning

The investment attractiveness of Latin American countries is scattered significantly. Chile, Mexico and Brazil lead while Venezuela, Jamaica and Ecuador lag behind (Figure 25). This wide spread is partly the result of a variation in policy support existing today in these countries. While Venezuela, Jamaica and Colombia don't have any policy support reported, other countries in the region, such as Chile, have an explicit political target regarding the renewable energy share and require power generators to meet minimum quotas of renewable energy. While a quota system may not address the need for PV specific support, the fact that some Latin American countries have defined renewable energy policy targets will help to unlock the potential in the region. Legal preconditions such as the permission for grid-connection of PV systems have evolved lately in important countries such as Mexico and Chile.

Except for Peru and Guatemala, the electrification rates are well above 92%, appearing rather high, which seemingly diminishes the potential for off-grid PV compared to other regions in the Sunbelt. However, there is already a significant amount of conventional mini-grids installed e.g. for industrial / commercial applications in remote operations. Turning such systems into hybrid systems including PV could be the lowest hanging fruit for rapid PV deployment. In addition, the PV potential for peak electricity is very high in countries such as Argentina, Dominican Republic, Jamaica and Mexico having a highly flexible generation mix (over 65%). The other countries in scope in this region show a more average flexibility around 30%.

In half of the countries in scope of the Latin American region, installed PV capacity has been reported to date (Figure 26) and Mexico has a significant manufacturing base for PV modules. Figure 26 shows also the installed capacity in the region and a selected number of projects announced. These add up to over 200 MW when implemented, suggesting that a significant growth of PV in Latin America is imminent.

SELECTED PHOTOVOLTAIC PROJECTS IN IN LATIN AMERICA



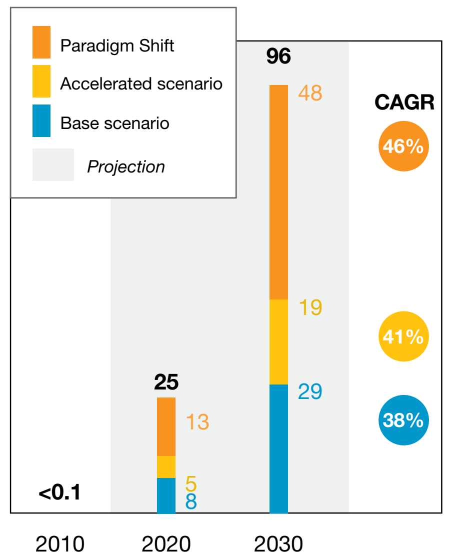
MEXICO	PERU	CHILE	ARGENTINA	BRAZIL
• Solar Project Solution announced to build 5 PV plants worth 130 MW	• Solarpack announced to build two 20 MW PV plants	• Solarpack announced to construct Chile's first solar plant of 10 MW and plans to build 6 such plants • Calama announced to build a 9 MW PV plant	• Comsa announced that the first PV plant with maximum installed potential over 1.2 MW will be built	• Energia Solar Brazileira announced to build large scale plant (>$ 42 mln) • Solar Energia announced to build a PV plant with 160 MW capacity by 2012

Source: A.T. Kearney analysis

Figure 26 : LA installed capacities and example projects

Figure 27 presents the regional PV potential for the LA region according to the three scenarios defined in section 2.3 of this study. The Accelerated scenario suggests an installed PV base of 13 GW by 2020, accelerating growth until 2030 to reach 48 GW. If a Paradigm Shift should occur, 25 GW seem possible in 2020 and a 2030 figure of 96 GW could be reached.

PROJECTION OF CUMULATIVE INSTALLED PV CAPACITY (GWp)



Source: A.T. Kearney analysis

Figure 27 : LA photovoltaic potential 2020/2030

The key barriers and preconditions identified in Section 2.3 hold true also in the case of Latin America. A number of specific preconditions for significant penetration of PV in the region are :

- **Know-how and perception** of PV to be improved by strengthening regional stakeholders with high PV competence. While renewable energy or solar energy associations exist for example in Brazil, Mexico or Argentina, they tend not to focus on PV. Also, given the lack of a significant domestic industry base, they operate in a difficult environment, where their lobbying power could profit from additional support also from players not yet present in LA countries. Increased awareness for the potential of PV among policy makers but also media and utilities would lay the foundation of improved PV support policies and removal of administrative barriers.

- Generalised **support policies** for renewables exist already in countries like Chile, Brazil, Mexico and Argentina. Nevertheless PV specific support needs to be created to unleash PV growth in these countries. In other countries such as Venezuela, Jamaica and Colombia, PV policy still needs to be created from scratch. Latin America as a whole can learn from existing policies in markets such as Malaysia or Thailand, where relatively better PV deployment exists already today.

- Also in the LA region, **finance** still constitutes a key barrier. The combination of private investment (utility investment) and international partnerships (World Bank, others) can provide necessary financing means for larger scale PV deployment in the region.

- **Grid connection** is absolutely key for large PV deployment. While undergoing testing e.g. in Chile, it is not the rule yet everywhere in the region. But the promising example of Brazil, which is moving towards obligating grid operators to connect PV systems starting in 2011, could serve as an icebreaker for PV growth.

- **Implementation and Service :** The example of Mexico, which uses its proximity to the US to export PV modules, shows that a PV manufacturing base can emerge even if the domestic market remains initially small. This provides a good supply base that can facilitate significant growth. Willingness to commit to the creation of a local manufacturing base would greatly enhance governmental attention towards supporting local PV deployment.

4

RECOMMENDATIONS TO KEY STAKEHOLDERS

TO UNLOCK THE SUNBELT POTENTIAL

A number of key stakeholders need to become active and collaborate to unlock the enormous PV potential of Sunbelt countries. While individual actions and well intended pioneering will move PV forward, unlocking the entire Sunbelt Paradigm Shift potential of over 1,000 GW by 2030 - with all its associated benefits - can only be reached with a high degree of collaboration.

Figure 28 identifies the key stakeholders and the main roles that they play in this effort.

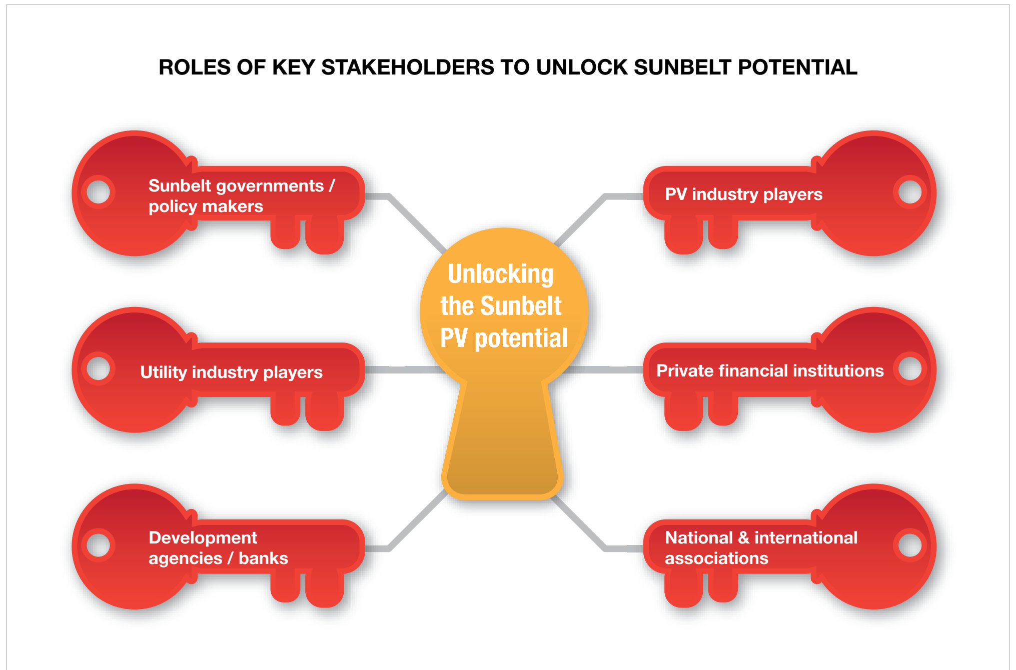


Figure 28: *Stakeholder overview*

Governments and policy makers are establishing the crucial framework for PV growth. In many cases in the Sunbelt, the fundamentals such as enabling grid connection and net metering, empowering local planning authorities to authorise PV facilities and enabling tax and custom exemptions for PV generated power or PV technologies are needed to facilitate "baseline" PV growth. For more ambitious PV penetration, reliable and sustainable support schemes such as feed in tariffs are needed to jump-start local PV deployment and enable the build-up of a domestic industry supplying, installing and maintaining PV systems at competitive prices.

While the role of governments can thus hardly be overstated, it is important to understand that their facilitation is often directly affected by the plans and perceptions of national utility sector players. The situation and objectives of power generation as well as on the grid operation players thus need to be considered. Here, PV needs to convince by its positive attributes as a peak source of energy that can, if installed close to consumption centers, actually decrease grid pressures and increase low carbon, domestic generation at almost zero marginal cost.

Concrete commitments of the PV industry are equally important in unlocking markets. Policy makers are not inclined to install favorable policies to jump-start markets if most of the value generation is created elsewhere. While the job creation argument is not equally applicable to all markets, it is worth pointing out that increasing portions of value creation are actually earned with installation and other downstream services, which are mostly local. But industry cannot remain passive and wait for the opening of key markets. Aggressive pricing and early market entry rather than aggressive lobbying for support might do more to open markets in the long term. Establishing significant coverage for client services and potentially even collaborating with competitors to ensure sufficient scale for national manufacturing bases could constitute new ways to "create" markets.

Development agencies and banks play an important role in the institution building as well as the financing of solar power development. In many Sunbelt countries, they are long standing advisors to government as well as energy sector players. They provide finance or co-finance where uncertainties are high and thus facilitate participation of private capital in infrastructure and other projects. Overcoming the apparent reluctance of development banks to endorse PV as a mainstream source of power is thus a key measure. This should facilitate important milestone projects which would open the PV market in certain countries where PV is currently simply not considered as a technological option.

Private financial institutions are more than willing to invest in sustainable energy applications worldwide, provided risk-adjusted returns justify the engagement. A key factor is risk perception, which often depends on an observer's personal background and experience. PV experienced financial institutions often have a European FiT market background. They need to understand the specific conditions of Sunbelt countries where the regulatory engagement is likely not to offer the same level of certainty. Local banks operating in the Sunbelt, however, usually have no significant experience with financing PV. Hence, partnerships between local banks and international partners, or in-house know-how transfers of large multinational banks with a presence in Sunbelt countries, would likely facilitate Sunbelt PV financing options.

Last but not least, national and international PV associations have an important role as facilitators of the discussion between industry, utilities, governments and the financial and development communities. They should provide a national source of reliable information and act as brokers and matchmakers between stakeholders to facilitate market opening. A particularly important field of activity is advocacy of sustainable levels of support.

5

HOW EPIA WILL HELP

MAKE THE SUNBELT VISION HAPPEN

As a Europe-based association of the PV industry with the world's largest international membership base, EPIA is firmly committed to supporting Sunbelt countries in developing their PV potential. As an active contributor to unlocking the PV potential in the Sunbelt countries, EPIA will :

- → Build awareness and know-how among government and energy sector decision-makers in key Sunbelt countries regarding the benefits of PV as well as sustainable support policies through actions such as policy briefings and expert exchanges.
- → Facilitate PV industry collaboration to open key Sunbelt markets, for exampleby organising fact finding missions for PV companies.
- → Improve the visibility and image of PV with international development banks and agencies with particular focus on on-grid PV by organising face-to-face expert meetings.
- → Liaise with financial institutions worldwide to prepare region/country specific financing solutions for PV investment in Sunbelt countries.
- → Encourage PV companies and institutions from Sunbelt countries to increase information flow and enable close interaction among sector players, e.g. by becoming a member of EPIA or other international PV or solar associations.
- → Support the strengthening / creation of national PV associations in emerging Sunbelt PV markets.
- → Elaborate market development roadmaps for selected Sunbelt countries.

If you are interested in any of the above activities, please consult EPIA's website **www.epia.org.**

APPENDIX

Key assumptions per country: GDP, Electricity Consumption, Macro economic stability and generation mix flexibility

Sunbelt Countries	GDP (2008 US$ Billions)	Electric power consumption 2007 (GWh)	Macro-economic stability(1) Ranking 0–10	% of generation mix flexible
Algeria	$166	30,555	8.98	99%
Angola	$84	3,24	4.50	16%
Argentina	$328	104,992	6.45	64%
Australia	$1,015	237,052	7.60	16%
Bangladesh	$79	22,776	5.75	94%
Botswana	$13	2,715	6.77	1%
Brazil	$1,575	412,689	4.88	7%
Cambodia	$10	1,348	4.00	96%
Cameroon	$23	4,953	7.07	33%
Chile	$169	55,202	7.47	33%
China	$4,326	3,072,673	8.22	2%
Colombia	$243	43,328	5.98	12%
Costa Rica	$29	8,305	5.18	8%
Dominican Republic	$45	13,523	5.47	77%
Ecuador	$54	10,515	6.65	48%
Egypt, Arab Rep.	$162	110,816	4.10	87%
Ethiopia	$25	3,172	4.60	4%
Ghana	$16	5,934	2.80	47%
Guatemala	$38	7,445	5.72	30%
India	$1,159	609,735	5.38	12%
Indonesia	$510	127,168	6.37	42%
Iran, Islamic Rep.	$286	165,116	3.80	91%
Israel	$202	50,275	6.03	30%
Jamaica	$14	6,803	2.08	96%
Jordan	$21	11,184	4.95	99%
Kenya	$30	5,71	4.05	29%
Kuwait	$148	43,134	8.72	100%
Lebanon	$29	8,965	3.80	94%
Libya	$93	23,883	8.65	100%
Malaysia	$221	97,391	6.67	64%
Mexico	$1,088	214,342	7.15	69%
Morocco	$88	22,077	7.07	36%

Table 01

Sunbelt Countries	GDP (2008 US$ Billions)	Electric power consumption 2007 (GWh)	Macro-economic stability[1] Ranking 0–10	% of generation mix flexible
Mozambique	$9	10,319	5.30	0%
Namibia	$8	3,219	6.03	1%
Nepal	$12	2,273	5.73	0%
Nigeria	$207	20,266	7.38	72%
Pakistan	$164	77,088	4.68	67%
Peru	$129	27,391	6.10	30%
Philippines	$166	52,001	5.90	40%
Qatar	$71	14,691	7.88	100%
Saudi Arabia	$468	175,074	8.10	100%
Senegal	$13	1,52	5.65	85%
Singapore	$181	37,94	7.10	100%
South Africa	$276	238,563	6.03	0%
Sri Lanka	$40	8,34	3.05	60%
Syrian Arab Rep.	$55	29,492	5.87	91%
Tanzania	$20	3,371	5.90	37%
Thailand	$272	137,675	7.28	70%
Tunisia	$40	12,765	6.28	99%
Turkey	$734	163,353	6.10	53%
UAE	$198	70,544	7.25	100%
Venezuela, RB	$314	84,554	5.63	28%
Vietnam	$90	61,97	4.77	36%
Yemen, Rep.	$26	4,495	4.10	100%
Zambia	$14	8,871	5.00	0%

(1) Scoring between 1 and 10 based on overall ranking of countries (source: World Bank)
Source: World Bank, World Economic Forum, A.T. Kearney analysis

Table 01

GWp potential by 2020 and 2030 for the Moderate, Advanced and Paradigm shift scenario

Country	2020			2030		
	Moderate Scenario	Advanced Scenario	Paradigm Shift	Moderate Scenario	Advanced Scenario	Paradigm Shift
Algeria	0.2	0.4	0.7	0.7	1.5	2.9
Angola	0.0	0.0	0.1	0.1	0.2	0.3
Argentina	1.0	1.7	3.3	4.2	6.9	13.8
Australia	2.6	3.9	7.8	9.5	14.2	28.4
Bangladesh	0.2	0.3	0.6	0.7	1.4	2.8
Botswana	0.0	0.0	0.0	0.0	0.1	0.1
Brazil	3.2	5.3	10.5	11.8	19.7	39.4
Cambodia	0.0	0.0	0.0	0.0	0.1	0.2
Cameroon	0.0	0.0	0.1	0.1	0.3	0.5
Chad	N/A	N/A	N/A	N/A	N/A	N/A
Chile	0.6	0.9	1.7	2.3	3.5	6.9
China	22.8	34.2	137.0	106.6	159.8	639.4
Colombia	0.2	0.4	0.8	0.8	1.5	3.0
Congo, Dem. Rep.	0.0	0.0	0.1	0.1	0.2	0.3
Costa Rica	0.0	0.0	0.1	0.1	0.2	0.4
Cote d'Ivoire	0.0	0.0	0.0	0.0	0.1	0.2
Cuba	0.0	0.1	0.1	0.1	0.2	0.5
Dominican Rep.	0.1	0.1	0.2	0.2	0.5	1.0
Ecuador	0.0	0.1	0.2	0.1	0.3	0.6
Egypt, Arab Rep.	0.7	1.3	2.7	2.8	5.6	11.3
Ethiopia	0.0	0.0	0.0	0.0	0.1	0.2
Ghana	0.0	0.0	0.1	0.1	0.1	0.3
Guatemala	0.0	0.1	0.1	0.1	0.2	0.5
India	12.9	19.3	38.6	45.0	67.5	135.1
Indonesia	1.7	2.9	5.7	8.8	14.7	29.3
Iran, Islamic Rep.	0.6	1.1	2.3	2.5	5.1	10.1
Iraq	0.1	0.2	0.3	0.3	0.6	1.1
Israel	0.4	0.7	1.4	1.7	2.8	5.6
Jamaica	0.0	0.0	0.1	0.1	0.1	0.2
Jordan	0.1	0.1	0.2	0.3	0.6	1.1
Kenya	0.0	0.0	0.1	0.1	0.2	0.4
Kuwait	0.4	0.6	1.2	1.6	2.6	5.3
Lebanon	0.0	0.0	0.1	0.1	0.2	0.3
Libya	0.1	0.3	0.6	0.7	1.4	2.8
Madagascar	N/A	N/A	N/A	N/A	N/A	N/A
Malaysia	1.4	2.1	4.1	5.9	8.9	17.8
Mali	N/A	N/A	N/A	N/A	N/A	N/A
Mexico	2.2	3.2	6.5	8.1	12.2	24.3
Morocco	0.1	0.3	0.5	0.5	1.1	2.2
Mozambique	0.0	0.1	0.2	0.3	0.5	1.0
Myanmar	0.0	0.0	0.1	0.1	0.1	0.3
Namibia	0.0	0.0	0.0	0.0	0.1	0.2

Table 02

Country	2020			2030		
	Moderate Scenario	Advanced Scenario	Paradigm Shift	Moderate Scenario	Advanced Scenario	Paradigm Shift
Nepal	0.0	0.0	0.0	0.0	0.1	0.1
Nigeria	0.1	0.1	0.3	0.3	0.6	1.1
Pakistan	0.2	0.5	0.9	1.0	2.0	4.0
Peru	0.1	0.2	0.5	0.5	1.0	2.0
Philippines	0.3	0.6	1.1	1.2	2.3	4.7
Qatar	0.1	0.2	0.4	0.5	0.9	1.8
Saudi Arabia	1.5	2.5	5.1	6.5	10.9	21.7
Senegal	0.0	0.0	0.0	0.0	0.0	0.0
Singapore	0.7	1.0	2.0	3.1	4.7	9.4
Somalia	N/A	N/A	N/A	N/A	N/A	N/A
South Africa	1.6	2.7	5.5	6.0	10.0	19.9
Sri Lanka	0.0	0.1	0.1	0.1	0.2	0.5
Sudan	0.0	0.0	0.0	0.0	0.1	0.2
Syrian Arab Rep.	0.1	0.2	0.4	0.4	0.9	1.8
Tanzania	0.0	0.0	0.1	0.1	0.1	0.3
Thailand	1.3	2.2	4.4	5.7	9.5	19.0
Tunisia	0.1	0.2	0.3	0.3	0.6	1.2
Turkey	1.7	2.9	5.7	7.3	12.2	24.4
Uganda	N/A	N/A	N/A	N/A	N/A	N/A
UAE	0.7	1.2	2.5	3.7	6.2	12.4
Venezuela, RB	0.2	0.4	0.9	0.8	1.7	3.3
Vietnam	0.5	1.1	2.2	2.9	5.7	11.4
Yemen, Rep.	0.0	0.0	0.1	0.1	0.1	0.3
Zambia	0.0	0.0	0.1	0.1	0.2	0.3

Source: A.T. Kearney analysis

Table 02

PV LCOE in 2010, 2020 and 2030 for the lower and higher bound of assumed PV system prices

Country	LCOE Base Case (€cts/kWh)			LCOE Advanced Case (€cts/kWh)		
	2010	2020	2030	2010	2020	2030
Angola	0.155	0.091	0.064	0.144	0.067	0.046
Argentina	0.165	0.097	0.068	0.153	0.071	0.049
Australia	0.166	0.098	0.069	0.154	0.072	0.049
Bangladesh	0.171	0.100	0.071	0.159	0.074	0.050
Botswana	0.139	0.082	0.058	0.129	0.060	0.041
Brazil	0.151	0.089	0.063	0.140	0.066	0.045
Cambodia	0.167	0.098	0.069	0.155	0.072	0.049
Cameroon	0.181	0.107	0.075	0.169	0.079	0.054
Chad	0.151	0.089	0.063	0.140	0.066	0.045
Chile	0.144	0.085	0.060	0.134	0.063	0.043
China	0.165	0.097	0.068	0.153	0.071	0.049
Colombia	0.176	0.103	0.073	0.163	0.076	0.052
Congo, Dem.Rep.	0.183	0.107	0.076	0.170	0.079	0.054
Costa Rica	0.153	0.090	0.064	0.143	0.067	0.045
Cote d'Ivoire	0.173	0.101	0.071	0.160	0.075	0.051
Cuba	0.141	0.083	0.059	0.131	0.061	0.042
Dominican Republic	0.160	0.094	0.066	0.149	0.070	0.047
Ecuador	0.201	0.118	0.083	0.187	0.087	0.059
Egypt, Arab Rep.	0.150	0.088	0.062	0.139	0.065	0.044
Ethiopia	0.136	0.080	0.056	0.126	0.059	0.040
Ghana	0.171	0.100	0.071	0.159	0.074	0.050
Guatemala	0.155	0.091	0.064	0.144	0.067	0.046
India	0.134	0.079	0.056	0.124	0.058	0.040
Indonesia	0.177	0.104	0.073	0.164	0.077	0.052
Iran, Islamic Rep.	0.158	0.093	0.066	0.147	0.069	0.047
Iraq	0.156	0.092	0.065	0.145	0.068	0.046
Israel	0.157	0.092	0.065	0.145	0.068	0.046
Jamaica	0.142	0.083	0.059	0.132	0.061	0.042
Jordan	0.157	0.092	0.065	0.145	0.068	0.046
Kenya	0.143	0.084	0.059	0.133	0.062	0.042
Kuwait	0.144	0.084	0.059	0.133	0.062	0.042
Lebanon	0.149	0.088	0.062	0.139	0.065	0.044
Libya	0.158	0.093	0.065	0.147	0.069	0.047
Madagascar	0.143	0.084	0.059	0.133	0.062	0.042
Malaysia	0.173	0.102	0.072	0.161	0.075	0.051
Mali	0.145	0.085	0.060	0.135	0.063	0.043
Mexico	0.147	0.086	0.061	0.137	0.064	0.043
Morocco	0.146	0.086	0.061	0.136	0.063	0.043
Mozambique	0.161	0.095	0.067	0.150	0.070	0.048
Myanmar	0.172	0.101	0.071	0.159	0.074	0.051
Namibia	0.128	0.075	0.053	0.118	0.055	0.038
Nepal	0.147	0.086	0.061	0.137	0.064	0.043

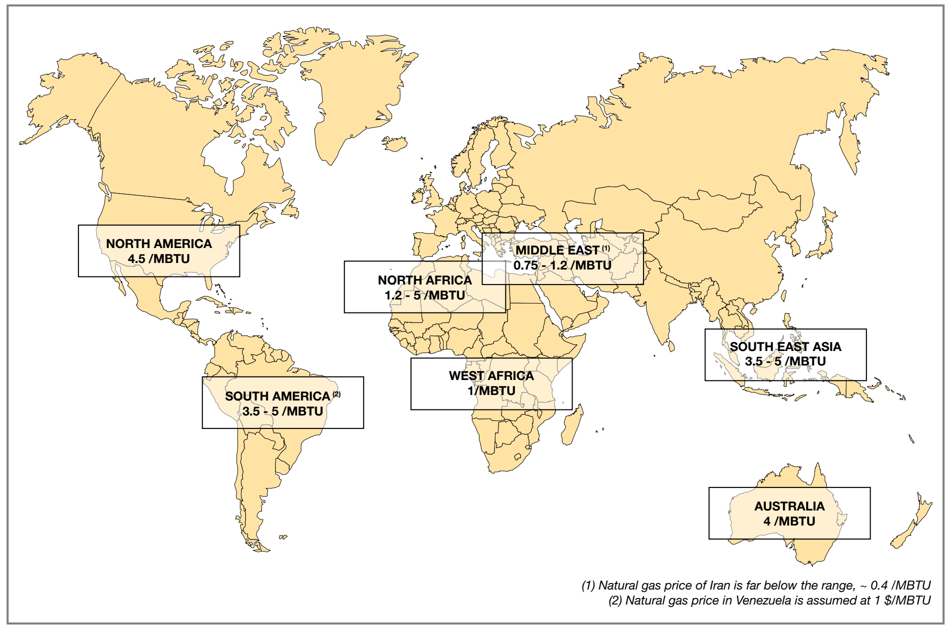
Table 03

Country	LCOE Base Case (€cts/kWh)			LCOE Advanced Case (€cts/kWh)		
	2010	2020	2030	2010	2020	2030
Nigeria	0.152	0.089	0.063	0.141	0.066	0.045
Pakistan	0.145	0.085	0.060	0.135	0.063	0.043
Peru	0.153	0.090	0.063	0.142	0.066	0.045
Philippines	0.182	0.107	0.076	0.169	0.079	0.054
Qatar	0.155	0.091	0.064	0.144	0.067	0.046
Saudi Arabia	0.142	0.084	0.059	0.132	0.062	0.042
Senegal	0.134	0.079	0.056	0.124	0.058	0.040
Somalia	0.150	0.088	0.062	0.139	0.065	0.044
South Africa	0.139	0.082	0.058	0.129	0.060	0.041
Sri Lanka	0.150	0.088	0.062	0.139	0.065	0.044
Sudan	0.129	0.076	0.053	0.120	0.056	0.038
Syrian Arab Rep.	0.158	0.093	0.065	0.147	0.069	0.047
Tanzania	0.161	0.094	0.067	0.149	0.070	0.047
Thailand	0.160	0.094	0.066	0.149	0.070	0.047
Tunisia	0.174	0.102	0.072	0.162	0.076	0.051
Turkey	0.175	0.103	0.073	0.163	0.076	0.052
Uganda	0.164	0.096	0.068	0.152	0.071	0.048
UAE	0.144	0.085	0.060	0.134	0.063	0.043
Venezuela, RB	0.149	0.087	0.062	0.138	0.065	0.044
Vietnam	0.164	0.096	0.068	0.152	0.071	0.048
Yemen, Rep.	0.126	0.074	0.052	0.117	0.055	0.037
Zambia	0.141	0.083	0.058	0.131	0.061	0.042

Source: A.T. Kearney analysis

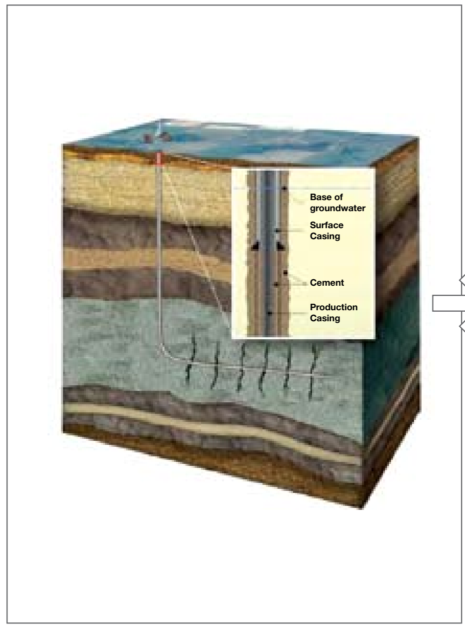
Table 03

REGIONAL GAS PRICE RANGES (2010, $/MBTU)

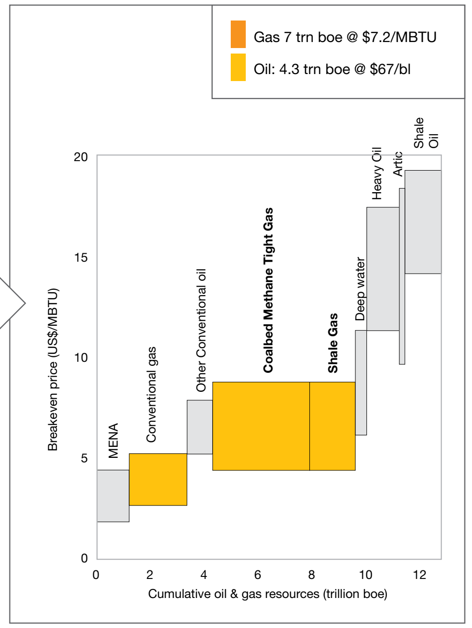


Lower end of the range represents countries with gas resources and upper end of the range reflects countries without gas resources, taking into account the transport costs and regional spot prices.

HORIZONTAL GAS WELL WITH MULTI-STAGE FRACTURING [1]...



... ENABLES ACCESS TO LARGE, MID-COST RESERVOIRS



Gas prices are expected to rebound after economic recession is overcome – unconventional gas will keep price increase modest despite significant demand growth

Source: (1) EnCana, quoted by Advanced Research International; (2) Statoil

GLOSSARY, KEY TERMS AND ABBREVIATIONS

ARE – Alliance for Rural Electrification

CAGR – Compound Annual Growth Rate: The year- over-year growth rate of an investment over a specified period of time

CAPEX – Capital Expenditure

CCGT – Combined Cycle Gas Turbine

CDM – Clean Development Mechanism

CO_2 – Carbon dioxide

CSP – Concentrating Solar (Thermal) Power

DC – Direct Current

DII – Desertec Industrial Initiative

Dispatchable – Ability of a system operator to use a form of generation to respond to system conditions. PV is dispatchable if combined with storage or by reducing demand.

EIA – Energy Information Administration (of the US Department of Energy)

EIA AEO – Energy International Administration Annual Energy Outlook

Energy pay-back time (EPBT) – the EPBT of PV systems gives the number of years a PV system has to operate to compensate for the energy used to produce and to install that system. After this period, it will produce net and clean electricity for the rest of its operational lifetime. The energy required to collect and recycle the end-of-life modules is also included in the calculation of the EPBT.

EPIA – European Photovoltaic Industry Association

EU – European Union

Fit – Feed in Tariff

GW – Gigawatt

HV – High Voltage

IEA – International Energy Agency

IGCC – Integrated Gas Combined Cycle

IMF – International Monetary Fund

Intermittent – the quality of switching on and off at regular or irregular intervals. PV is an intermittent source of energy. But it can be predicted and the variations of supply diminish the broader the system boundaries are defined.

Investment Attractiveness – the general investment climate of a country based on general macro-economic figures as well as the availability of support system for renewables.

JRC – Joint Research Center (EU)

LCOE – Levelised Cost of Energy. Total cost per kWh of output over the lifetime of a power generation installation.

MBtu – Million British Thermal Units

MW – Megawatt

Mini-grid – local power grids connecting one or several power generators to local customers. Hybrid Mini Grids use at least two different generation technologies such as diesel generators and PV.

NREL – National Renewable Energy Laboratory

OECD – Organization of Economic Cooperation and Development

Off-grid Installation – power generation facilities that are not connected to a national power grid at the transmission or distribution level. This includes mini-grids, which are considered "off-grid" as long as they are not interconnected with the national grid.

PV – Photovoltaic

PV Attractiveness – the attractiveness that PV has for a country as an element of its electricity supply system. Not to be confused with the market size or ease of market entry that a given country might represent for a PV industry player or investor.

PV Know-how – skills and experience needed to understand the various PV technologies, their respective suitable applications and associated business models and financial implications and benefits.

PV Opportunity – the opportunity that PV represents to a country based on a high level of attractiveness of PV as a mainstream source in the country's energy supply as well as an investment and political climate that make the deployment of PV a realistic option. The opportunity can be large in small countries as well as large countries as it takes the perspective of a given country, not an external investor.

PV Potential – the absolute installed capacity potential that can be reached in a given timeframe. Potential is somewhat correlated with the opportunity in terms of how fast PV deployment can be achieved. But it also reflects the overall size of the electricity market as an important driving factor. PV Potential indicates to investors the size of the potential overall market depending on each particular scenario.

PV power installed – PV power installed is measured in Wp (Watt peak) and refers to the nominal power under Standard Test Conditions STC (1000W/m^2/year, 25°C, 1.5 AM)

Sunbelt – Countries as defined on map

TWh – Terawatt hour

WACC – Weighted

WEO – World Energy Outlook

NOTES

European Photovoltaic Industry Association
Renewable Energy House
Rue d'Arlon 63-67, 1040 Brussels - Belgium
Tel.: +32 2 465 38 84 - Fax: +32 2 400 10 10
com@epia.org - www.epia.org

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