Why Solar Power is an economic opportunity – now!

Large solar plants in Tunisia are competitive with power generation from de-subsidized natural gas in Tunisia. Rooftop solar photovoltaics (PV) are competitive with peak power natural gas power plants. Together they could lower the power and transmission bills in Tunisia immediately by peak shaving and by a higher diversity of sources beyond imported natural gas. In a second stage, large Concentrated Solar Power plants (CSP) could deliver ever more clean energy with facilities that can dispatch power from storage during day or night.

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In the first part of our series on renewable energy in Tunisia we showed that electricity from wind power instead of natural gas could save Tunisia 500-800 millions Dinars (240-360 Million Euros) yearly [1]. The economies by wind power correspond to 50 Millimes DT (2.3 €Cents) per kilowatt-hour (kWh) of natural gas power replaced right from the start – and some 150 millimes DT (4.9 €C/kWh) after five years, by injecting power from good wind sites.

Similar economies can be expected with a growing share of solar power generation. Solar PV power generation has grown by a factor of 10 between 2007 and 2012, from 6.7 to 93 TWh per year [2] and new installations growth continues (Figure 1).

While *solar hot water* installations are well known and established in Tunisia, we here take a look at *electricity generation* from solar. Solar power can be generated from three different sources in terms of costs and markets:

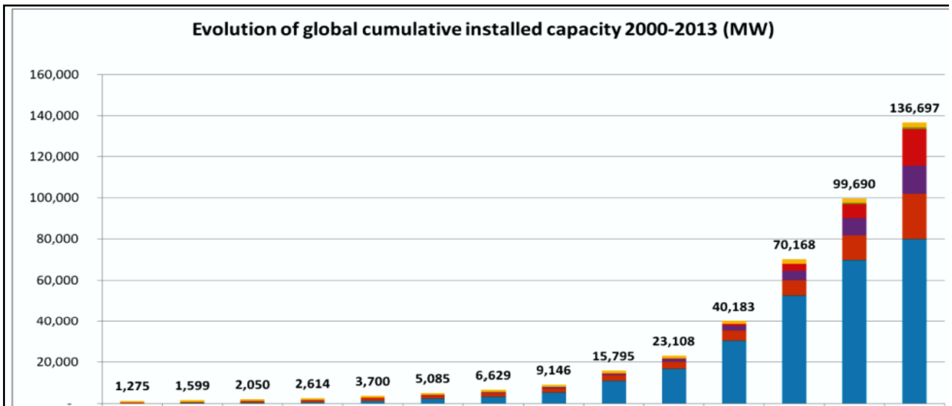
- *Distributed PV systems* such as solar roofs. Their priority use is to service consumer's captive load at the point of use, with excess production injected to the grid.
- *Solar PV farms:* Megawatt or multi-megawatt sized PV installations who inject their power into the transmission grid.
- *Concentrated Solar Power plants* (CSP): Multi-megawatt sized CSP installations are based on steam turbine power generation from solar heat. The heat is collected by mirrors focused on a tower or by parabolic trough technology focused on hot tubes. Modern CSP plants include heat storage for power supply at night or dispatching.

The technology

Solar PV modules transform sunlight directly into electricity. *Distributed power generation* means that sites are embedded in distribution grids, using interconnection facilities that already exist. In the short run it is cheaper to integrate small PV systems in existing distribution grids than to build new connections for solar PV farms from remote areas. Distributed PV is set on roofs, walls, parking lots or on empty spaces near the point of use, and respecting existing grid capacities (Figure 5).

Solar farms or *solar parks* are large, ground mounted systems; they can be placed at special locations such as deserts with high insolation. In this case the cost of interconnection can be essential and must be considered as an additional part of overall costs, while solar roof investments at low shares of overall power generation normally do not cause significant interconnection costs.

PV systems work with direct insolation or with diffused sunlight, the latter with



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ROW	751	807	887	964	993	1,003	1,108	1,150	1,226	1,306	1,590	2,098	2,098	2,183
MEA	-	-	-	-	1	1	1	2	3	25	80	205	570	953
China	19	24	42	52	62	70	80	100	140	300	800	3,300	6,800	18,100
AMERICA	21	24	54	102	163	246	355	522	828	1,328	2,410	4,590	8,365	13,518
APAC	368	496	686	916	1,198	1,502	1,827	2,098	2,628	3,373	4,951	7,513	12,159	21,992
Europe	116	249	381	580	1,283	2,264	3,258	5,274	10,970	16,777	30,352	52,462	69,699	79,952
TOTAL	1,275	1,599	2,050	2,614	3,700	5,085	6,629	9,146	15,795	23,108	40,183	70,168	99,690	136,697

Source: EPIA

Figure 1: Growth in MW (2000-2013) of PV systems globally installed (source: EPIA)

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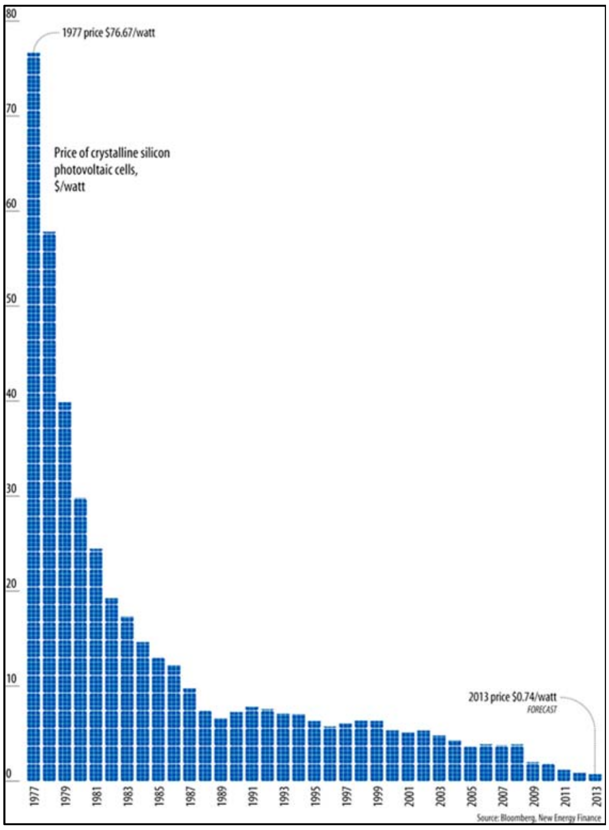


Figure 2: Price in US$/Watt of crystalline silicon photovoltaic cells 1976-2013

(Source: BNEF)

a reduced productivity regarding to name-plate capacity. Record amounts of new solar capacity have been installed over the last years worldwide. PV has become a viable option for power generation even in less sunny countries such as Germany, the UK, the US or China.

Concentrated solar systems (CSP) deliver electricity by working with vectored mirrors that beam solar radiation to a focus point (Figure 4). The heat carrier is hot air, hot water or fluid hot oil. A thermal power generator with a steam turbine generates the electricity. To reach sufficient temperatures, CSP systems need a high level of direct solar insolation. They hence are sited in deserts or semi-deserts in countries such as Spain, California or Chile.

In Morocco, the Ouarzazate CSP plant with 160 MW first-

Figure 4: Concentrated solar systems: trough collectors in front line, tower behind (Source: Abengoa)

Figure 5: solar roof with roof-mounted panels

(source LBL)

stage capacities and with storage facility is in construction. It is the first-of-its-kind in North Africa and should be able to provide electric power at least for three hours after sunset. It is expected to be operational in 2014/15.

Non-module costs increasingly decisive

The price of solar cells and modules has dropped to a level that is 80 percent cheaper compared to ten years ago (Figure 3). Non-module costs – so called balance of system (BOS) –have become more important.

The size of installation, the degree of competition on the local PV market, the distances for interconnection grid and the availability of surface areas for solar use can be important for BOS costs. In general BOS costs along with customer acquisition, transaction costs and capital costs are dropping, but in some markets utilities use detrimental regulations to keep solar out of the market.

In competitive markets such as Germany, full installations costs go from 1-2.40 Euro/Watt while in the US prices are higher – at 2-5 US Dollars/Watt – including higher expenses for permissions and capital, import duties for modules of Chinese origin, metering costs of utilities and less experienced solar companies.

Overall, total costs for PV are converging worldwide. The projection is that at a $3 per watt for the cost of installed solar, another 100 GW could be economically installed without relying on any subsidy programs. [3]

Balance of system cost Forecast for 10MW Fixed Tilt c-Si in US

U.S. Utility BOS Costs	2012E	2013E	2014E	2015E	2016E
Inverter	$0.18	$0.17	$0.14	$0.11	$0.10
Structure	$0.18	$0.17	$0.15	$0.14	$0.14
Foundations	$0.10	$0.09	$0.09	$0.08	$0.08
Labor	$0.27	$0.25	$0.24	$0.22	$0.20
EBOS	$0.22	$0.20	$0.19	$0.18	$0.16
Misc	$0.22	$0.22	$0.20	$0.19	$0.18
Total	$1.17	$1.10	$1.01	$0.92	$0.86

Source: Citi Research, Greentech Media

Figure 6: Balance of systems cost (non-module cost) of solar power, forecast in US-Cents/Watt

(Source: Citigroup)

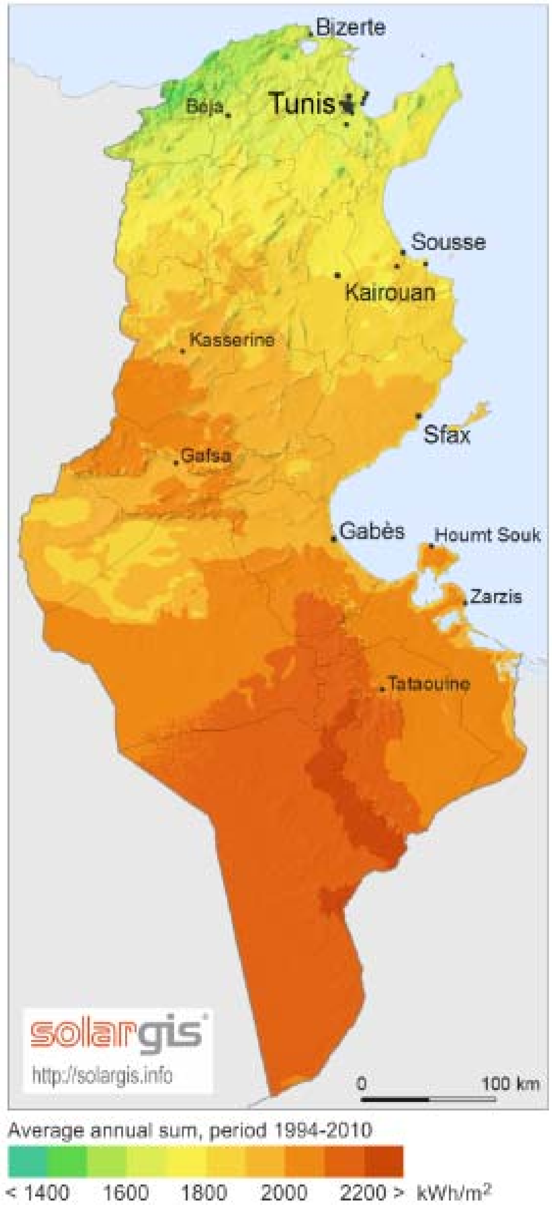


Figure 7: direct solar irradiation in Tunisia

(Source: Solar GIS, Geomodel Solar)

Solar advantage for MENA countries

In Tunisia, PV installations might still be rare and therefore more costly compared to markets such as Germany or Italy – but this might change soon. The price per kWh in Tunisia could be one of the lowest worldwide due to the intensity of sunshine and the high number of sunshine hours per year.

With some 36’000 Megawatt PV Germany is the world champion of solar installations; the amount of full-load-hours is 950 only per year.

In Tunisia the amount of full-load-hours per year is 1400-2200. In general in North Africa and Middle East (MENA), solar irradiation is 50-120 percent higher than in Germany. This creates a local advantage regarding generation costs. The retail price for solar power could be 30-50 percent cheaper in Tunisia than in Germany, provided that hardware costs, permissions, interconnection, maintenance and access to finance can be arranged as cheap as in Germany.

The higher number of sunshine hours is responsible for the fact that Italy today has a higher share of solar energy per capita – 7.8 percent of total power consumption – than Germany with 6.2 percent.[4] Italy has a name-plate capacity of only 17,3 GW installed while its neighbor to the North has 35.5 GW – but with less sunshine. The higher insolation is responsible not only for the higher production in Italy but also for a cheaper price. Capital and installation costs per peak kW capacity meanwhile are roughly the same for both countries. But in Italy, there is 30-50 pe3rcent more sunshine depending on location.

The number of full-load hours is a statistical measure for the production (efficiency) of an installation compared to its nameplate capacity. It does not reflect how many hours a solar installation is delivering in reality. A solar power installation delivers power as soon as there is light – some 12 hours over 24 as an annual average. For more than 99 percent of the day, PV systems might run at partial load in countries where sun light is diluted by clouds or mist.

There is another important difference between solar and wind: The sun is not shining at night while winds can blow day and night. If power generation has to match demand it makes sense to mix different technologies from different locations: wind, solar PV, concentrated solar thermal, hydro and biomass. Their profiles may differ regarding day time, weather and season. Some renewable energies work in positive or negative correlation to each other; some can be stored (hydro, biomass and solar heat).

Figure 8 shows the renewable energy mix in California (USA) for a single day (24 hours). Solar power is injected to the grid together with wind, hydro, biomass and geothermal power. Solar PV delivers its highest contribution at noon while wind power is more prolific during nights than during days there.

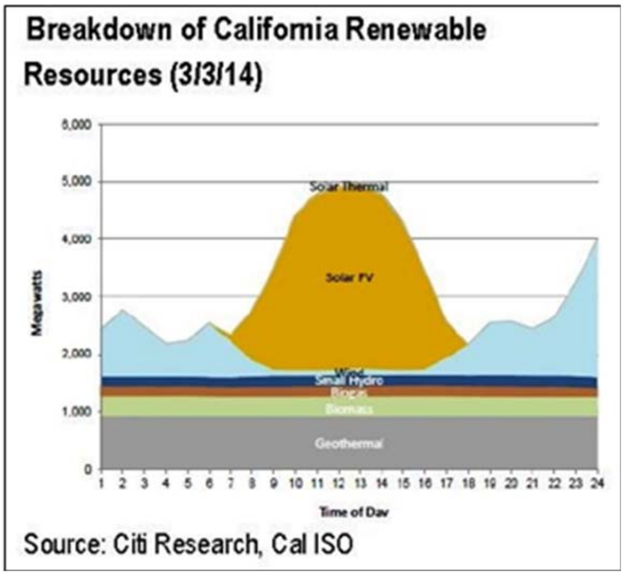


Figure 8: renewable energy production over one day’s time (24 hours) in California

(Source: Citigroup research / Cal ISO)

In a diversified portfolio, different renewable energies do complement each other. On a cloudy day it might be windier than normal.

Backup demand for power gaps can be delivered by natural gas plants, biomass, hydro or batteries. Storage needs should not be calculated along a single renewable energy source, but along all renewable energies combined.

Different solar markets

The economics of solar power depend strongly on local conditions including insolation, grid regulations, market conditions and locational opportunities. The strongest growth of PV worldwide actually is recorded for residential solar ("distributed solar") on roofs. Solar roofs are competitive in ever more countries with retail prices representing full, non-subsidized costs for generation and grids (Figure 9).

Retail prices include the cost of energy *and* the cost for grids. In many countries grid charges are as high or higher as the charge for energy that comes with electricity. Local self-generation at the point of use hence has an economic advantage because it saves energy costs and grid costs which combined come in much higher than the wholesale market price for bulk power.

However, some utilities make targeted efforts to limit or reverse the increase of distributed PV or wind, arguing that these programs increase their cost for managing the grid, and that the costs for solar connections and backup are borne by consumers that have not installed solar.

Given the low cost, including local industry, security-of-supply and environmental benefits of solar compared to the conventional energies, these arguments often seem somewhat short sighted. Often they reflect a strong will to defend monopolistic positions and rents of incumbent power companies who control the market due to vertical integration and control of grid rates.

In "dynamic" power systems such as emerging economies, wind power and solar PV are cost-effective to meet incremental demand, and their expansion can bring many benefits: local industrial growth, new jobs, reduced power imports, security of supply and no need for water cooling.

With proper investments, a flexible system can be built from the start, parallel with the deployment of variable renewables. "Emerging economies really have an opportunity here – and they should reap the benefits," a new study of the International Energy Agency concluded [5].

These benefits of distributed generation are

- Avoiding the purchase of energy from other, exhaustible and more polluting sources
- Avoiding the need to build additional power plant capacity to meet peak energy needs
- Providing energy for decades at a fixed price
- Reducing wear and tear on the electric grid, including power lines, substations, and new power plants.

Three payment schemes for distributed PV

An increasing number of solar systems in the future might acquire a battery for storage. Meanwhile, in the not so distant future, the attraction of solar PV today depends largely on the value of the power injected – that is the price paid per kWh by the local utility.

By giving solar power a guaranteed minimum tariff and priority access within the grid, a utility acknowledges the environmental harm of its fossil fuel energy generation. Different schemes can help to make distributed generation financially appealing:

- *feed-in-tariffs (FITS):* the electricity distributor by law is obliged to pay a fixed amount of money over the lifetime of a solar array for each kWh injected to the grid.
- *Avoided cost method:* a legal compensation per kWh is paid, derived from de-subsidized power acquisition costs from other sources within the local distribution grid, including avoided costs for energy, transmission and line losses.
- *net metering:* the meter turns back when excess power is fed to the grid. The power injected is paid by a deduction of monthly bills at retail prices. Excess power at the end of the billing cycle can be paid or then transferred to the next billing cycle.

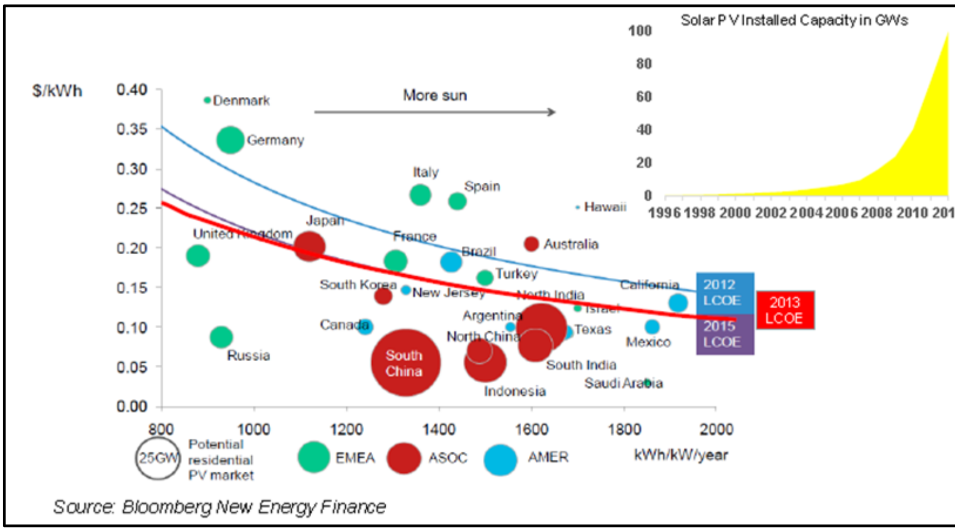


Figure 9 Retail prices, solar insolation and size of retail power markets in different countries (source: BNEF)

All three payment systems are performance based. No give-away capital grants or state subsidies for power plants are needed. Performance based rates for power injections stimulate a reliable delivery, because the price paid depends purely on kWh delivered. Risks of technology, production and maintenance are shifted from public utilities to private investors, households, farmers, funds or independent power producers (IPPs) investing into solar or wind.

With module prices dropping, self-consumption of solar power or

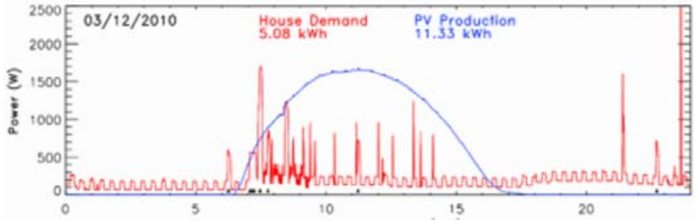


Figure 10: power production from rooftop solar PV (blue) and household consumption (red).

(source: L. Miloshevich solar PV System homepage)

injection to the grid is getting ever more popular for factories, shops, apartment or single residential houses. And with batteries added to the system, a PV system with storage can be more reliable than power from the grid in many parts of the world.

New Tunisian Bill

For Tunisia, a new *Bill concerning the production of electricity from renewable energy* published in early 2014 is discussed in Parliament. The bill proposes a framework for self-consumption, sale to the Tunisian power utility (STEG) as unique buyer/unique seller and for exports.

Self-Consumption and Net Metering

Producers of electricity from renewable energy are entitled to sell their electricity surpluses to STEG who commits to buy these surpluses under the framework of a standard agreement. Exact rates will be decided by order and do not make part of the law.

Individual demand for power (Figure 10, red line) normally does not match with power generated on roofs (blue line). Therefore a fair treatment of surplus production by the distribution grid operator is essential for the viability of investments.

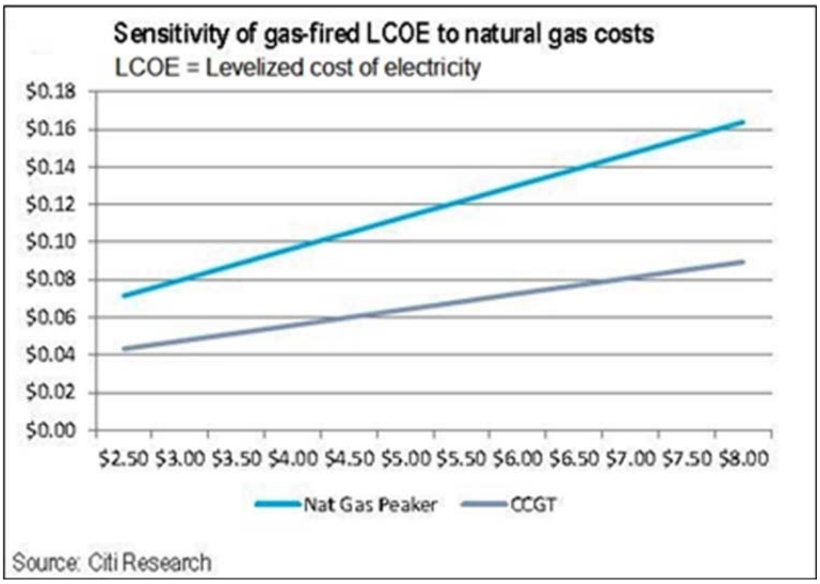


Figure 11: the levelized Cost of Electricity (LCOE) of combined cycle natural gas turbines versus single cycle gas plants, depending on natural gas price (source: Citibank Research)

A solar roof strategy needs a "welcome culture" by utilities and distribution grid managers. Charging high fees for metering, grid connections, permissions or for residual energy will hamper solar power generation and reduce the amount of energy the sun could deliver.

By buying the solar power supply from solar roofs, a utility can shave the peaks of demand effectively and reduce costly peak generation (see below).

In Tunisia, subsidies for grids and natural gas reduce the profitability of distributed solar investments.

Voltage tariffs for retail clients stood at a low 133-186 Millimes-DT in 2011 (6-8.5 €Cents/kWh).

Electricity subsidies amounted to 126 Millimes-DT (5.7 €C per kWh) in 2012 [6].

With subsidies for natural gas at this high level it is difficult to promote solar energy – despite its abundance as a free, domestic resource that could be earned profitable from roofs compared with the price of de-subsidized natural gas.

The cost per kWh for rooftop solar is dependent on the size of the installation. In Germany it comes in between 1.2 €/Watt and 2.5 €/Watt; this would translate into costs of 175-350 Millimes-DT (8 to 16 €C/kWh), depending on the level of interest rates.

The full cost of power from natural gas in Tunisia was at 260 Mill-DT per kWh (12 €Cents/kWh) [7].

Medium and large rooftop systems could be profitable immediately if natural gas would be de-subsidized. A huge and profitable solar market could emerge.

Rooftop solar competitive with peak supply

For national power company STEG, acquiring solar power from small rooftops or bigger solar farms would be a bargain because some of the natural gas plants are very expensive. "For peak power generation, solar is increasingly attractive vs. gas peakers from a cost and fuel diversity perspective" says a report of Citigroup Research, one of the big banks in the US [8].

Baseload power plants typically run throughout day and night. Combined cycle gas turbines (CCGT) can produce at efficiencies of 50 percent or slightly more. This means that for two kWh of natural gas you create one kWh of electricity.

For peak power though, CCGT are not used for their low flexibility. Instead peak plants are in service with a higher heat rate. Natural gas is burned in a single cycle in more flexible but less efficient plants. The efficiency of peak natural gas plants is at 20-25 percent. This means that 4 -5 kWh of natural gas are needed to produce one kWh of electricity.

Figure 11 shows the cost difference between

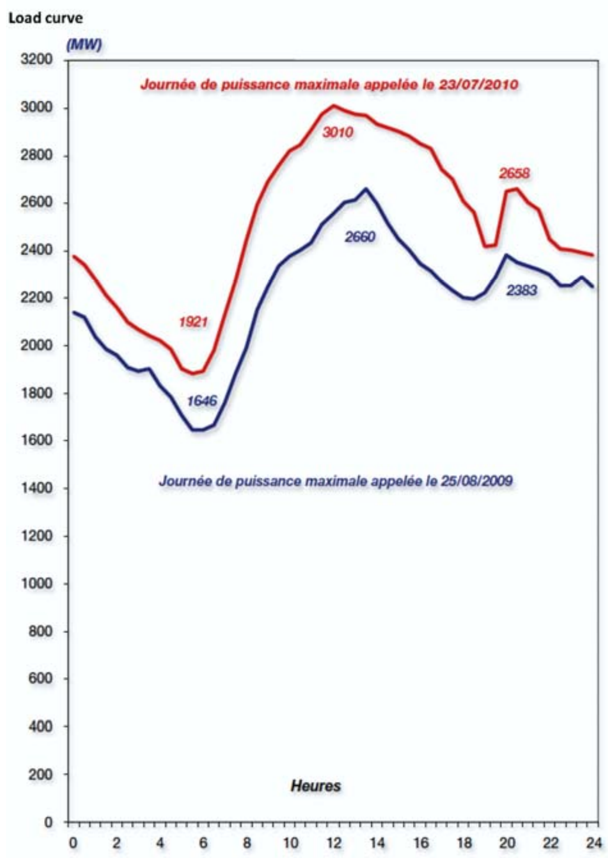


Figure 12: Tunisian daily load curve 2009 and 2010 (Source: STEG/ANME)

highly efficient CCGT plants with natural gas and peak plants with natural gas for the US.

Natural gas in the US natural is sold at 4.80 US$ per MMBTU only (1.2 €Cents/kWh), but the full cost of peak electricity is quoted to be 10-11 US-Cents/kWh. (7.2-8 €C, 160-175 Millimes-DT/kWh) [9].

In Europe and Tunisia, natural gas is more costly than in the US. With a price for of 3.3 €Cents/kWh or 73 Mill-DT/kWh, peak power from single cycle plants would translate into costs of 280-330 Millimes-DT (13-16 €C/kWh) – a price that is in the range of small and medium sized solar roofs. Large, ground-mounted solar could be much cheaper than peak power from natural gas.

Peak demand in Tunisia has been rising year after year and the highest charge of power plants and grids appears at noon, exactly when solar power could supply this peak at a cheaper cost from the sun as a domestic resource. [10]

The increase of power from solar roofs and ground mounted systems therefore would be highly beneficial for Tunisia:

- PV systems could reduce peak demand from the most expensive natural gas plants. Subsidies paid by the Tunisian government could be reduced, too.
- A second relief comes from the less strained grids; each kWh produced from rooftops at noon can reduce the charge of transmission and distribution grids.

For these reasons rooftop solar installations must be perceived as a competitive source of power in Tunisia *today*, despite its still elevated cost compared with wind power or, eventually, with natural gas power from CCGT plants.

Redirection of subsidies

A reduction of electric power subsidies would be highly beneficial as an incentive for solar investments from independent power producers or individuals. To fulfill the goals of the Tunisia Solar Plan [11] it seems indispensable to redirect subsidies. As a social relief for poor people they should be handed in a technology-neutral way.

A solar boom would create a boom for installers, but permission, financial conditions and billing systems should be streamlined too. The solar expansion would come at low cost: Investments into the transmission grid could be restrained or delayed and capital would come from private households and small businesses eager to save money by building their own rooftop power plant.

Distribution grids will need adaption for reversal power flows. These one-off investments are not expensive however. Modern PV systems are able to deliver reactive power and operational voltage regulation; by reducing voltage fluctuations and by using free solar insolation they strengthen security of supply, even at night.

Large solar plants competitive

Large solar arrays can be substantially cheaper than solar roofs. According to STEG, combined cycle gas turbines in Tunisia produce electric power at full cost of some 8-10

Figure 13: Solar farms in deserts can produce huge amounts of power with preferred insolation – but they need to be connected to the load centers

(Source: Photon magazine)

€Cents per kWh (de-subsidized).

At this cost of electricity, large solar farms in the South of the country are able to compete with natural gas. With natural gas prices on the rise they can become highly profitable.

The economics of large solar plants are different from solar roofs. First, installations come at a significantly lower price due to economies of scale. Second, they normally are built at sites where solar insolation is highest – in the prolific deserts for example.

Optimized siting is an important factor in more than one aspect:

- Risks of getting a no-sunshine-day in the desert is much lower than in the cloudier North. This means that from desert solar farms power can be provided when production from solar roofs is rather modest.
- The insolation in the desert can be higher than in populated cities and therefore the generation cost is lower.
- Because there are few siting constraints such as houses, roads or agriculture, large sized investments can be realized at lower costs and they bring economies of scale.

The favorable siting and cost comes at a price though: the cost for connection and transmission can be higher, including grid expenses and higher line losses to reach the consumers.

In an equilibrated portfolio however, central solar PV plants and rooftop solar should both find their place, together with wind and other renewable energy sources.

In Germany with annual insolation of some 950 full load hours per year, the feed-in-tariff for PV power goes from 9.19 to 14 €C/kWh (202-300 Millimes-DT). With 1900-2200 solar full load hours in the desert, Tunisia should be able to produce solar power for 4-5 €C/kWh (90-110 millimes DT) provided the capital and service can be provided at roughly the same conditions as in Germany.

The importance of Feed-in-Tariffs

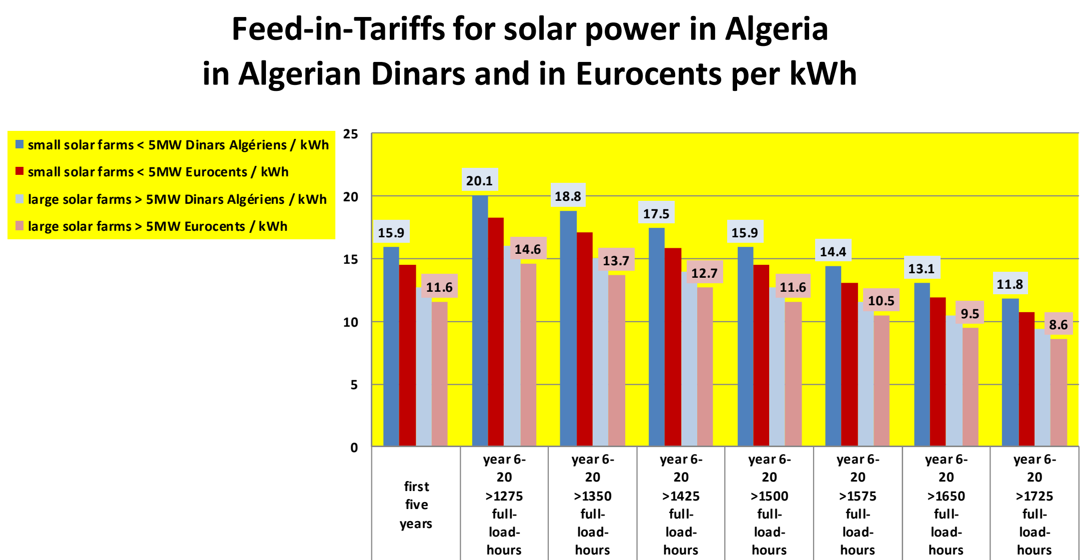
Large solar farms cannot be financed by self-consumption or net metering. They need stable power purchase agreements or feed-in-tariffs (FITs).

The essence of FITSs is a stable and appropriate price for each kWh injected to the grid over the period necessary to write down a PV power installation. The feed-in-price amount can be close to the market price of electric power (or even below), but the level needs to be predictable and solid for years. FITs can vary depending on productivity at a specific site.

Their objective is to deliver investment security. Small, medium and large scale projects are getting "bankable" for public, private or cooperative investors; the risk of revenue is reduced and therefore, the interest rates for credits are much lower compared to market based revenues or compared to other instruments for the promotion of renewable energy.

FITs per kWh may differ by technology and size of installations, and they can be reduced for *new investments.* Existing facilities, however, need reliability for financial survival because their financial burden represents a historic cost that barely can be influenced. Some 90 percent of the cost of solar and wind farms are finance cost (interest and depreciation). Only a fixed price regime – similar to power purchase agreement (PPA) in many competitive power markets – is able to lower risk premiums effectively and therefore reduce the core cost of any renewable energy investment.

To preempt insecurity or financing constraints, the consumers of electricity should bear the cost of FITs by a small additional charge for grid-delivered electricity. This additional cost normally is outweighed by savings from lower wholesale power prices. With growing shares of renewable energy, the price levels for electricity on many power markets have started to be a moving target. When the sun is shining or the wind is blowing, renewable energies "make" the price of power at the power exchange: the most



	first five years	year 6-20 >1275 full-load-hours	year 6-20 >1350 full-load-hours	year 6-20 >1425 full-load-hours	year 6-20 >1500 full-load-hours	year 6-20 >1575 full-load-hours	year 6-20 >1650 full-load-hours	year 6-20 >1725 full-load-hours
small solar farms < 5MW Dinars Algériens / kWh	15.94	20.08	18.83	17.45	15.94	14.43	13.06	11.8
small solar farms < 5MW Eurocents / kWh	14.49	18.25	17.12	15.86	14.49	13.12	11.87	10.73
large solar farms > 5MW Dinars Algériens / kWh	12.75	16.06	15.06	13.96	12.75	11.54	10.44	9.44
large solar farms > 5MW Eurocents / kWh	11.59	14.60	13.69	12.69	11.59	10.49	9.49	8.58

Figure 14: structure of the Algerian solar feed-in-tariff, introduced April 2014 (source: Journal Officiel de la République Algérienne)

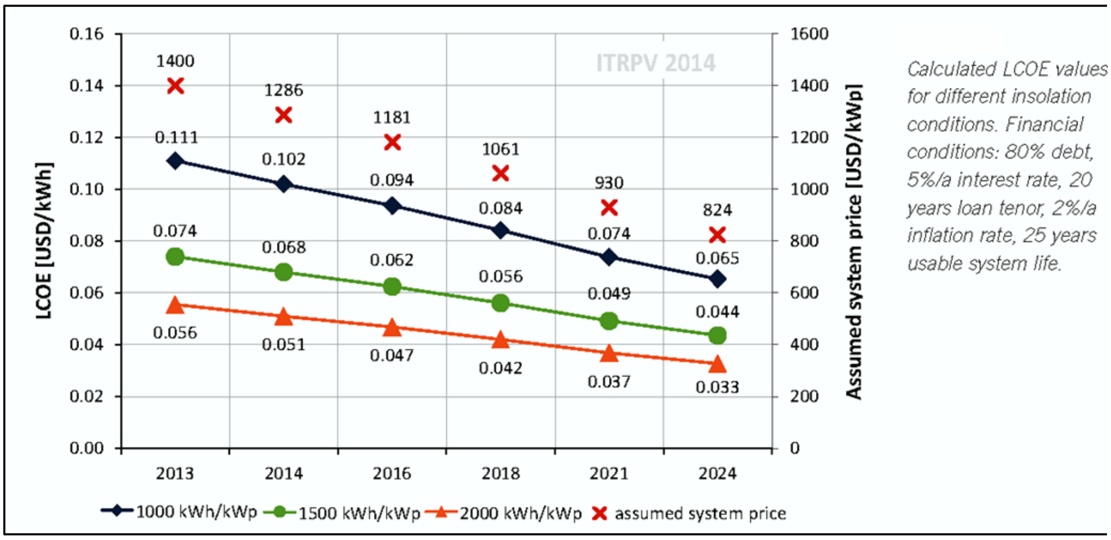


Figure 15: Expected cost reductions in US-Cents/kWh for solar power at sites with 1000, 1500 and 2000 full-load-hours per year (source: International Technology Roadmap for Photovoltaic ITRPV 2014 edition)

expensive power plants are closed and this means that the price in general will fall with the amount of renewable energy in the grid.

Grid parity means that rooftop generation is as cheap as conventional power from grid. For investment security and to ensure debt service and repayments, legal FITs should persist even when *grid parity* or *whole sale market parity* is reached. Additional to FITs, soft loans from national or international credit facilities can reduce hurdles even more. Access to capital at moderate interest rates is given in many countries such as by KfW (Kreditanstalt für Wiederaufbau / Bank for Reconstruction) in Germany or by the Brazil National Development Bank (BNDES) which both are state controlled.

Feed-in-tariffs for solar power in Algeria

In April 2014, Algeria has introduced feed-in-tariffs for solar PV. The price guarantees are valid for 20 years.

For large installations with more than 5 MW nameplate capacity a uniform tariff for the first five years of 12.75 Algerian Dinars (11.59 €C) per kWh is paid. The uniform compensation is based on reference solar output of 1500 full-load-hours. From 6th to 20th year the price guarantee ranges from 9.44 - 16.06 Dinars (8.58 - 14.60 €C/kWh) depending on the number of full-load-hours per year at the site.

For small installations with less than 5 MW a uniform tariff for the first five years of 15.94 Algerian Dinars (14.5 €C) per kWh is paid. From 6th to 20th year of the installation the price guarantee ranges from 11.8-20.08 Dinars (8.68-15.15 €C/kWh) depending on the full-load-hours per year 1275 - ≥1725 hours per year [12].

An undisclosed limit of the yearly number of hours for which the FITs will be paid has also been introduced. In the regulation there is no reference of a cap for the volume of capacity that can apply for the FITs.

Solar PV still is a young technology – and we will see more expansion over the next years, with continuous cost reductions expected.

To create a solar boom in Tunisia, a reliable framework is necessary, with long term goals and intermediate milestones closely monitored by government and Parliament.

In all developed markets, feed-in-tariffs for solar have been reduced for new installations – while preserving the old standard offer contracts. By introducing a rate that shifts downward depending on full load hours at a certain site, excessive profits can be preempted up from the start.

Any good framework needs to consider local conditions of production: investment costs, connection costs, annual insolation, capital costs and costs for maintenance need to be calculated in a fair way, based on empirical data from reference installations.

Tenders

Tenders for solar or wind power installations are a more competitive way to create diverse investments from a range of professional companies. But there are challenges with this instrument:

- Tendered installations might be positioned in sparsely populated regions with very high solar irradiation, though this could imply additional transmission costs. Installations with less transmission needs would suffer from their siting close to load centers and with lower annual insolation;
- Tenders always put an initial limit on investments. Small investors have to expect hurdles compared with international companies. Feed-in-tariffs allow schemes with small investments, embedded in the distribution grids at low cost for interconnection.

Any system with tenders should look after small investments, too, by continuing with feed-in-tariffs up to a certain size (10 MW for example).

Public savings

Like wind power, solar systems do not need conventional fuels and have no fuel costs or fuel cost risks such as power plants with gas, coal fuel oil or uranium. The price per kWh is perfectly predictable, based on upfront capital outlays, finance conditions, maintenance costs and annual insolation per m^2.

Tunisia indeed could save billions of Dinars over the next decades by building a 100 percent domestic supply from home grown wind and solar.

With more wind and solar a more flexible grid management is necessary. The cost for integration of solar power largely depends on the availability of flexible power plants such as hydro storage facilities, natural gas plants, biomass plants or batteries. The new supply would fare well with existing natural gas plants which could be used for backup purposes. Power supply immediately would be less vulnerable and costly with reduced imports from neighbors.

Many industry observers predict price reductions of another 30-40 percent over the next ten years. This would make solar power ever more competitive, and it would make sense for Europe to be delivered with clean power from Tunisia instead of volatile gas deliveries from Russia.

The role of CSP

Tunisia cautiously should look at CSP plants too, such as in construction in Morocco, Spain or Chile. With additional wind and PV in the grid, CSP can deliver a flexible source for power management. On the long run CSP will be able to substitute natural gas plants, but even more options can be found and should be evaluated in economic terms: backup from biomass, pumped hydro (with sea water) or small batteries for households who can work as a black-out protection facility too.

CSP uses thermal steam turbines that can be fed by heat from molten salt storages. Molten salt systems such as AREVA's draws molten salt from a ‚cold' tank (290°C), uses the heat from mirrors to heat it to as high as 550°C, and passes that hot liquid to a separate tank for storage. When needed, the high-temperature molten salt passes through a heat exchanger to produce steam for electricity generation. The salt then returns to the ‚cold' tank and the process is repeated in a closed-loop system.

By using new, innovative facilities, energy from solar irradiation can be transferred from daytime to nighttime. A storage facility can deliver a bridge for minutes or for hours with low production due to clouds, low wind or sunset.

CSP still is in an early stage of industrial development. But credit institutions such as the World Bank, the European Investment Bank or the African Development bank share the risks of the new technology by contributing loans. Tunisia should get access to these new opportunities and put itself on the map as a partner within a Europe-Africa power cooperation that serves both parts.

Acceleration and revision of law needed

For Tunisia however, a competitive solar industry can grow only when the speed of solar installations growth can be accelerated. The first draft of the *Bill concerning the production of electricity from renewable energy* should be improved:

- All renewable energies should get a guarantee for open access to the power grid.
- Priority dispatch for energy with nearly zero marginal costs such as wind and solar should be confirmed by law.
- a transparent and reliable scheme for appropriate finance of each kWh of clean power over a fixed period of 20 years should be ,
- Feed-in-tariffs should consider the effective full-load-hours of an installation; variations of productivity regarding solar irradiation of different sites should be respected by tariff schemes guaranteeing equal returns for investors.
- For fair rules, an independent regulator is a necessity. Conflicts between independent power producers and single buyer STEG should be submitted to independent arbitration.
- Exoneration form permission fees for solar installations, at least for roof top solar, should be confirmed by law.
- A one-stop-shop (guichet unique) for solar park permissions with maximum delays fixed by the law could be helpful.
- Introduction of up-to-date technical standards for PV, using medium and large installations as a source for reactive power
- Grid extension programs should not be the burden of new investors. Maximum grid delays should be fixed by law, including compensation rules in case that timely connection should fail.

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