THE FUTURE OF SOLAR ENERGY IN ALEPPO

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CARL JOHANNES MUTH

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THE ALEPPO PROJECT

مشروع حلب

Worldwide Photovoltaic (PV) Capacity

(Source: IEA ; statista)

2007	2015	2050
9,1 GW	229,3 GW	4,600-6,300 GW

Area required to provide global electricity demand using PV panels = 496,805 KM^2 or about the size of Spain

Syria's electricity generation

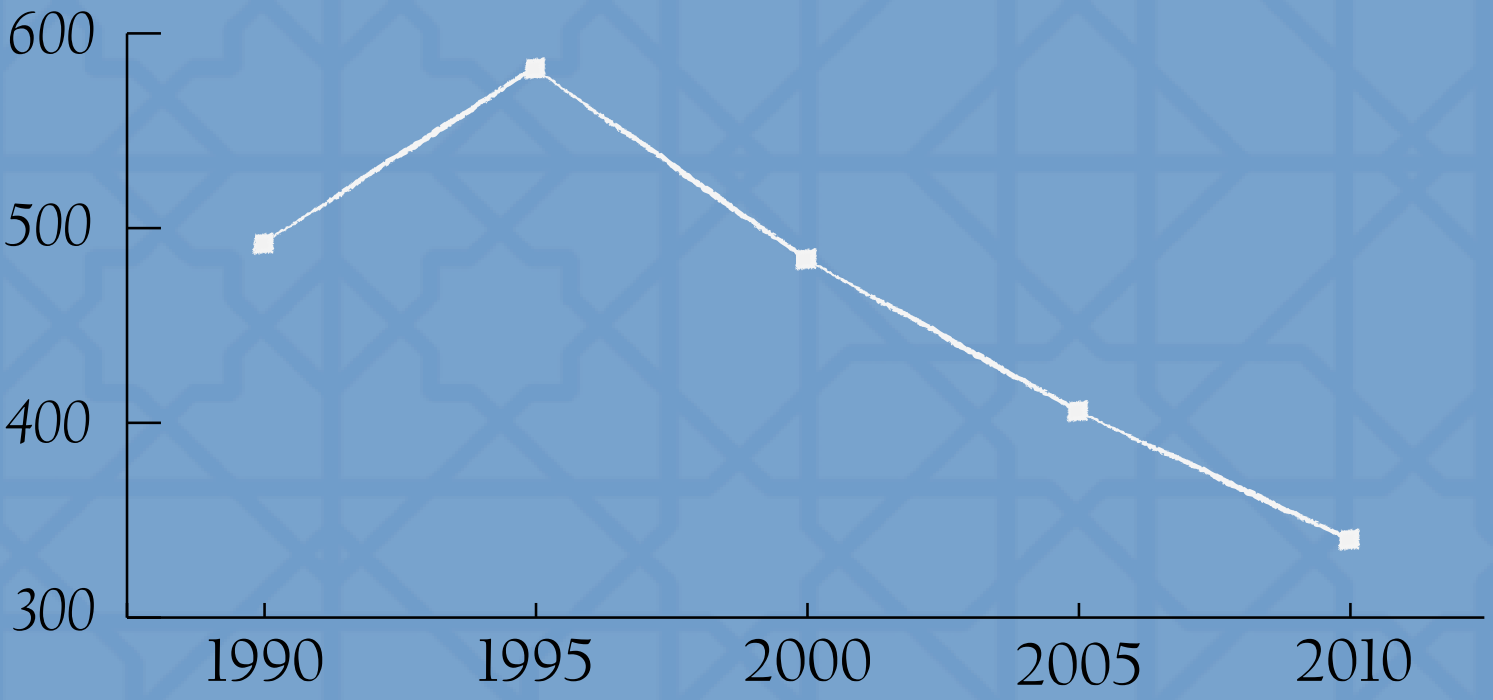
(Source: IEA)

2010		2013	
94	% FOSSIL FUELS	82	% FOSSIL FUELS
6	% RENEWABLE ENERGY	12	% RENEWABLE ENERGY

Syria's crude oil and condensates production 1990-2010

(thousand barrels per day)

(Source: IEA)



THE FUTURE OF SOLAR ENERGY IN ALEPPO

SUMMARY

Large solar arrays offer one of the best ways to restore power to Syrian cities like Aleppo. Cheap to manufacture, quick to assemble and with low running costs, dispersed solar generation systems would also add resilience to an energy system that has been severely damaged by war and will remain at risk of violent attack.

Reconstruction requires electricity, but providing it in conflict situations has proven onerous in Iraq and Afghanistan. Both countries had hoped to rely on oil and natural gas to generate electricity, but redeveloping centralized power generation and widespread distribution networks has proven almost impossible due to insurgencies. Power stations and power lines make tempting targets because of the impact an attack has on large numbers of people.

Solar panels would help to off-set some of these security concerns. Small arrays providing power to local communities would likely be protected locally and would offer less tempting targets for dramatic attacks. Solar panels operate independently—blowing up one does not cause the whole system to go off line. Reducing investment in vulnerable distribution networks would mean less waste when power lines get attacked.

Syria is perfectly located in the sunbelt and there are large areas of desert land to the east of Aleppo that could provide power to the city. Photovoltaic systems work well on sunny days, but may eventually need to be combined with more expensive concentrated solar power arrays with the ability to store energy.

Photovoltaic solar systems do not answer every energy problem—its inability to store energy is a serious limitation—but it could provide cost-effective, resilient energy in a complex post-conflict environment in a way that has been impossible using thermal generation. On top of the obvious environmental benefits, it would enable Syria to use its oil and gas, if the battered industry can be rebuilt, to earn export income.

Getting power running 24/7 is vital to restoring confidence in post-conflict economies and enabling refugees to return home. Although people in countries recovering from war often voice their frustration with power cuts, relatively little emphasis has been placed on this as a post-conflict priority. More than a decade after the invasions of Afghanistan and Iraq, their capital cities still suffer irregular power supplies, undermining confidence in weak governments and aiding insurgencies. Restoring stability to Syria means keeping the lights on.

Reconstructing energy systems will be central to any post-war recovery in Aleppo. Syria was once the leading oil and gas producer in the eastern Mediterranean, but output has fallen to a fraction of pre-conflict levels. Damage to infrastructure, the loss of key personnel and continued fighting have meant that power only reaches the city for a few hours a day at best. People have turned to expensive diesel generators and solar panels for their needs, but the rebuilding of the city's economy will eventually require significant investment in restoring energy.

Elsewhere in the Middle East, oil and gas revenues have been used to support reconstruction, but with very mixed results. Iraq should have had sufficient resources for reconstruction, but insecurity and corruption meant that little has been rebuilt. If the future Syrian government has control over oil-rich areas in the east of the country, it will have at least modest resources to support reconstruction. But the likelihood is that these revenues will be captured by past or emerging elites. Besides oil and gas, which were in decline even before the war, Syria urgently needs to diversify its energy sources. Reconstruction can present an opportunity to move towards green energy such as solar power, which has been widely neglected in the region due to the prevalence of hydrocarbons.

Aleppo's climate and geographic location meet the necessary requirements to use solar power systems and photovoltaics have become significantly cheaper and more efficient. Although solar power needs to be combined with other sources to ensure a steady flow of electricity during adverse weather or at night, preassembled solar panels can be put together to develop huge fields relatively rapidly. Solar power would also contribute to energy security, the return of businesses and the normalization of society in the Aleppo region.

CURRENT STATE OF SYRIA'S ENERGY SYSTEM

Syria's energy sector was in dire straits long before the civil war. At its peak in 1996, it produced up to 583,000 barrels of oil per day (b/d).[1] Due to a lack of investment and the technical challenges of operating mature fields, oil production declined to 383,000 b/d in 2011. Natural gas production of about 316 million cubic feet per day (2011) has always been insufficient to export significant volumes.[2] Nevertheless, the state's oil and gas sector accounted for approximately 25 per cent of government revenues and fueled 94 per cent of Syria's thermal power generation. The remaining six per cent of the country's effective generating capacity came from hydroelectric power plants and other renewable energy (0.3%).[3]

Civil war has significantly reduced Syria's energy capacity. Continuing clashes will cause it to worsen further. The oil industry has been torn to pieces, cut off from refining and controlled by either the regime, ISIS or opposition groups. Given Coalition airstrikes on well-heads and transport facilities in ISIS-controlled areas in October 2015, it is impossible to estimate total oil production. Syrian government figures

suggest a heavy and growing dependence on crude oil imported from Iran (up to 90 per cent) to supply the refineries in Banias and Homs that processed about 98,000 b/d of crude oil in 2015.[4]

The gas and electricity sector, especially its networks, have survived, but are critically damaged. As a result of the repeated sabotage of high voltage lines and gas pipelines, a third of Syrian gas-fired power stations were dormant as of 2013. Clashes have led to a sharp downturn in generating capacity to 2,000 MW.[5] By the end of 2015, Aleppo residents mostly relied on their own generators or bought power from neighborhood producers.

Aleppo's main supplier of electricity in the past was a 1,000 MW thermal power plant at As-Safir in the southeast of the city. In 2013, however, the plant went out of service because of malfunctions caused by fighting nearby. The plant later fell under ISIS control.[6] In late February 2016, regime forces recaptured As-Safir Plains and its power station. According to the Director General of Aleppo Power Company, Abdelilah Talalini, power returned gradually to Aleppo from the beginning of March.[7] Although Aleppo's four-month blackout ended, natural gas production seems insufficient to bring the plant to full capacity.

It will take years to return energy facilities, especially costly distribution systems, to pre-conflict levels. Reconstruction will likely take place in an environment of insecurity. Solar power offers a way to produce decentralized power that is at less risk of disruption and may be more cost-effective in the short term than the expensive replacement of a damaged network.[8]

SOLAR POWER: PHOTOVOLTAICS OR CONCENTRATED SOLAR POWER?

Solar power offers two routes to electricity generation.[9] The European leader in solar, Germany, has used photovoltaics (PV), which now accounts for six per cent of the country's net power output.[10] The United States and China[11] have favored the construction of huge solar power plants using concentrated solar power (CSP) as parabolic trough systems.[12]

CSP systems use parabolic troughs to focus sunlight so that its heat creates steam that turns turbines to generate electricity. Parabolic trough systems have two large advantages: they require less land than photovoltaics and by harnessing special fluids, heat can be stored and used later to run the turbines when the sun is not shining. Solar thermal power plants can also be combined with biomass power plants (hybrid operations) to ensure a steady flow of energy. However, CSP technology requires facilities that are expensive to purchase and time-consuming to build.

The other main solar power technology uses the photovoltaic effect–in which light striking certain materials creates an electric current.[13] Photovoltaics can convert light directly into electricity but cannot store energy. Preassembled solar cell panels are constructed quickly and have become significantly cheaper in recent years.

PV technology should be considered first due to its practicality. CSP as a potential energy source could come at a later stage of reconstruction because of its ability to store energy.

ALEPPO'S LOCATION AND CLIMATE

Aleppo, Syria's economic capital, is located in the northwest of the country around 120 km inland from the Mediterranean on a plateau (390m NN) along the Quweiq River. Due to a mountain range west of the city that largely blocks the effects of the sea,[14] Aleppo has a cool steppe climate.[15] Short, cool, wet winters are followed by long, dry, hot summers with an average annual precipitation of 395 mm (around 50 rainy days) and more than 3,000 hours[16] of sunshine per year.[17]

The city is surrounded by fertile land used for livestock, grains and olives to the north and west. To the east, however, Aleppo borders the dry and mainly empty areas of the Syrian Desert—an ideal spot for solar energy fields. This is supported by Aleppo's location at a latitude of 36° North in the sunbelt—the most suitable area for the use of solar thermal power and solar power in general.[18]

SAFETY AND ENERGY SECURITY

"The energy sector has become a major focus for targeted attacks and is now among the top five most targeted sectors worldwide."[19] The vulnerability of nuclear power plants to deliberate attacks by hijacked planes is a potential threat that receives much attention, even though it represents only an extreme scenario. Nuclear power plants are secured by a wide range of protection mechanisms and many countries, including Syria, do not have them. However, costly energy pipelines, their pumping systems, electrical transmissions grids and power plants represent attractive and fairly easy targets. Even the partial destruction of a gas or oil power plant or its pipelines often means the loss of energy for an entire region.[20]

This applies especially to Syria. Even though a peace agreement could be reached and the civil war could end in the near future, the region will remain highly unstable. Reconstruction will have to consider issues of security and resilience, particularly in the vulnerable energy sector. Energy clusters in the form of small solar energy fields could provide electricity close to where it is needed, thus reducing the risk to plants and pipelines. In addition, each solar field consists of hundreds of thousands of independent solar panels. Therefore, partial destruction would affect only a section but not the entire solar field, making it a less attractive target.[21]

INCENTIVES FOR EUROPE TO INVEST IN SOLAR ENERGY

Europe is now facing the implications of the Syrian conflict with a large inflow of refugees. Due to internal pressures to lower these flows, European leaders will be expected to create incentives to encourage Syrians to return home eventually. Peace is a necessary but insufficient condition. Syrians must be able to regain a sense of hope for a better future if they are to go home. Among other key factors, a trouble-free energy supply is an essential foundation for "the return of small business and the development of a sustainable economic base"[22] to lower significantly Syria's unemployment of over 50 per cent and its poverty rate of 85 per cent.[23] Here solar power is likely to provide a rapid improvement in energy supplies. Furthermore, developing the sector would reduce dependence on imported energy and allow that money to be spent elsewhere.

Another reason to move towards solar energy is the environment—especially in regards to the recently ne-

gotiated Paris Agreement (COP21). In December 2015, 195 countries adopted the first-ever legally-binding[24] global action plan to put the world on track to reduce emissions and global warming.[25] Investment in solar technology as a part of Aleppo's reconstruction instead of focusing on coal and gas as energy sources would be an important shift for donors and would underline their commitment to limiting climate change.

Realistically, climate change will not drive policy in this area whereas the economic opportunities available to European companies might. Many European states are major players in the production and export of solar technology. Ailing German photovoltaic companies, hit by strong competition from China, would benefit from projects in Syria.

Solar power systems have very low maintenance requirements, have few moving parts and typical warranties will cover a system for 25 years. Therefore, an investment in solar technology offers low lifetime costs. Syrian refugees could be trained to install and maintain the technology to ensure sustainability.

EXPECTED OBSTACLES AND RUSSIA'S INTERESTS

There are some potential obstacles to using solar power in Aleppo. Besides security in Syria, there is a lack of local expertise in the field and there are potential spoilers, not least the Russian government which has played a major role in the conflict.

In 2013, the Russian energy company Soyuzneftegaz acquired a permit for joint exploration in Syria's territorial waters but suspended its plans until the conflict is resolved. Russia is now aiming to take over the Syrian energy sector with the expectation that there may be significant oil and gas reserves off the coast. According to Russian press reports, Assad has already signed an agreement that gives Russia the right to operate in Syria even after a change of government. The regime of Bashar al-Assad on the other hand hopes that the new deal will help rehabilitate the energy sector and produce new supplies of power in the short to medium term.[26]

Solar fields could significantly lower the demand for gas-generated power, which would run counter to the interests of the Kremlin. Navigating a difficult political and security environment, particularly around Russian interests, will be at the center of any solar project given the possible obstacles that could be put in its way.

LEARNING FROM OTHERS

The wheel will not have to be reinvented to help Aleppo develop solar power, but it is essential to be realistic. This did not occur with the DESERTEC project. The 2009 project included an ambitious plan to build a 100 GW CSP field—equivalent to 20 per cent of Europe's total electricity demand—in the Sahara Desert by 2050. Due to projected costs of about $400 billion, the project was labeled as utopian and abandoned in 2013.[27] However, the completion of Noor 1 near Ouarzazate[28] in Morocco shows that a plant can be built in a developing country. The entire solar plant[29] is expected to cost $9 billion and to produce up to 580 MW when finished, becoming the world's largest solar power station.[30]

Switching to solar power has been a topic of discussion in Aleppo since 2005. In 2009, Qalamoun Uni-

versity launched a solar energy project that has not been completed. More recently, solar energy has been used in Aleppo on a small scale to cover blackouts resulting from attacks on energy facilities.[31] Experiences learned in the past few years could help avoid mistakes and simplify operations. For that reason, those already working in the area in Aleppo should be included in further project planning.

CONCLUSION

A steady energy flow at a reasonable cost is vital for any economy and society. Under normal conditions, energy can be supplied by any source. In terms of Aleppo and Syria now, it is almost limited to solar power. Preassembled solar panels can be rapidly constructed. Pipelines are not needed. Solar lowers energy dependency and in the form of energy clusters it represents a far less attractive target for attacks. The geographical conditions are good and international donors have incentives to invest in it.

Technical limitations of photovoltaics to convert only direct sun light into energy represent a major problem. Also political obstacles, such as the unstable situation in the region as well as Russia's specific interest in Syrian energy, must be considered and addressed to find a possible solution.

ENDNOTES

1 Proven reserves of crude oil (2015): 2.5 billion bbl. EIA. "International Energy Data and Analysis: Syria." 24 June 2015. Accessed 14 March 2016. https://www.eia.gov/beta/international/analysis_includes/countries_long/Syria/syria.pdf.

2 Proven reserves of natural gas (2015): 8.5 billion cu feet. EIA. "International Energy Data and Analysis: Syria." 24 June 2015. Accessed 14 March 2016. https://www.eia.gov/beta/international/analysis_includes/countries_long/Syria/syria.pdf.

3 EIA. "International Energy Data and Analysis: Syria." 24 June 2015. Accessed 14 March 2016 https://www.eia.gov/beta/international/analysis_includes/countries_long/Syria/syria.pdf.

4 Around 10,000 b/d of crude oil are produced from government-controlled fields. Butter, David. "Salvaging Syria's Economy," Middle Eastern and North Africa Programme. Chatham House. March 2016. Accessed 16 May 2016. https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2016-03-15-syria-economy-butter.pdf p.17.

5 Generating capacity fell from a pre-conflict total of about 9,700 MW to 7,900 MW in 2013. Butter, David. "Salvaging Syria's Economy," Middle Eastern and North Africa Programme. Chatham House. March 2016. Accessed 16 May 2016. https://www.chathamhouse.org/sites/files/chathamhouse/publications/research/2016-03-15-syria-economy-butter.pdf p.20.

6 Al-Khatieb, Mohammed. "Power outages add to Aleppo's suffering." Al-Monitor. 12 August 2014. Accessed 15 March 2016. http://www.al-monitor.com/pulse/originals/2014/08/aleppo-syria-electricity-outage.html#

7 Sabbagh, Hazem. "Electricity Returning Gradually to Aleppo Province." SANA. 05 March 2016. Accessed 14 March 2016. http://sana.sy/en/?p=71238.

8 As Ilyés pointed out in her paper about the reconstruction of Beirut, redevelopment must be realistic. Syria will not be an energy leader in the region again soon, but has to focus on more modest aims i.e. satisfying the basic needs of the population. Ilyés, Ilona I. "Rebuilding Downtown Beirut." The Aleppo Project, November 2015. Accessed 18 May 2016. http://www.thealeppoproject.com/papers/reconstructing-downtown-beirut/

9 According to the U.S. Energy Information Administration's estimate, around 500,000 square kilometers of solar panels would be needed to provide for global energy consumption in 2030 (200 trillion kilowatt-hours). This is equivalent to the area of Spain. Land Art Generator. "Total Surface Area Required to Fuel the World with Solar." 13 August 2009. Accessed 17 May 2016. http://landartgenerator.org/blagi/archives/127.

10 Renewable energy accounts for about 30 per cent (19,4TWh) of the net generated electricity in Germany (2015) and is composed of wind (13.3%), biomass (7.7%), hydro (3%) and solar power (6%: 38,2 TWh). Strom-Report: Zahlen, Daten, Fakten – Stromerzeugung in Deutschland 2015. Accessed 17 May 2016. http://strom-report.de/strom-vergleich/#stromerzeugung-2015.

11 China is building a 25.5km² CSP plant which will supply electricity for approximately one million households in Qinghai province. Business Standard. "China starts building its largest solar plant." 22 July 2015. Accessed 5 March 2016. http://www.business-standard.com/article/news-ians/china-starts-building-its-largest-solar-plant-115072200487_1.html.

12 A wide range of other concentrating technologies exist, including the compact linear Fresnel reflector, the Stirling dish and the solar power tower.

13 Encyclopedia Britannica. "Photovoltaic effect." Accessed 4 March 2016. http://www.britannica.com/science/photovoltaic-effect.

14 So-called rain shadow effect.

15 A cool steppe climate describes an area with dry and hot summers and rainy winters with 80% of the annual precipitation.

16 In comparison, Germany has only around 1,800 sunshine hours per year.

17 Climates. "Sunshine Guide to the Aleppo Area, Syria." Accessed 2 March 2016. http://www.climates.com/ASIA/PDF/SYR01ASA.pdf.

18 Almasoud, A.H. and Gandayh, H.M. "Future of solar energy in Saudi Arabia," Journal of King Saud University - Engineering Sciences. Volume 27, Issue 2, July 2015. Accessed 20 March 2016. http://www.sciencedirect.com/science/article/pii/S1018363914000221. pp. 153–157.

19 Projects Monitor. “Energy sector under risk!” 15 February 2014. Accessed 2 March 2016. http://www.projectsmonitor.com/guest-articles/energy-sector-under-risk/

20 Coal power plants do not require pipelines, however, the destruction of such a big “energy producer” would have the same effect on the region.

21 Wind power provides the same benefits and therefore could become a source for Syria’s future sustainable energy mix. However, the use of wind power requires intensive research for suitable areas (wind canals) which makes quick implementation after a peace settlement difficult.

22 Ilyés, Ilona I. “Rebuilding Downtown Beirut.” The Aleppo Project. November 2015. Accessed 18 May 2016. http://www.thealeppoproject.com/papers/reconstructing-downtown-beirut/

23 Spiegel. “Fünf Jahre Syrienkonflikt: Ein Land am Boden.” 17 March 2016. Accessed 17 March 2016. http://www.spiegel.de/politik/ausland/syrien-infografik-ein-land-am-boden-a-1082410.html

24 However, the agreement will only become binding if 55 participating countries that produce over 55% of the world’s greenhouse gases ratify the accord.

25 See United Nations. “Adoption of the Paris Agreement.” FCCC/CP/2015/L.9/Rev.1, 12 December 2015. Accessed 19 March 2016. https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf

26 The New Arab. “Assad preparing to handover Syria’s energy sector to Russia.” 15 February 2016. Accessed 14 March 2016.https://www.alaraby.co.uk/english/indepth/2016/2/15/assad-preparing-to-handover-syrias-energy-sector-to-russia

27 Calderbank, Selwa. “Desertec abandons Sahara solar power export dream.” EurActiv. 9 August 2013. Accessed 16 March 2016. https://www.euractiv.com/section/trade-society/news/desertec-abandons-sahara-solar-power-export-dream/

28 Ouarzazate was originally the chosen location for the DESERTEC project.

29 Noor 1, 2 and 3 will use CSP technology. Noor 4 will be a PV solar plant.

30 The world’s largest solar farm in terms of installed capacity is the PV power station Solar Star in California. Completed in 2015, the 579 MW solar installation spreads over 13 km² (approximately 1,800 soccer fields) using 1.7 million solar modules that generate enough electricity to power around 250,000 households. Mortenson. “Solar Star I & II – Project Facts.” Accessed 18 March 2016. http://www.mortenson.com/solar/projects/solar-star-i-and-ii; Last SunPower. “The Solar Star Projects – Project Facts.” Accessed 18 March 2016. http://us.sunpower.com/utility-scale-solar-power-plants/solar-energy-projects/solar-star-projects/; Nelson, Arthur. “Morocco poised to become a solar superpower with launch of desert mega-project.” Guardian. 26 October 2015. Accessed 3 March 2016. http://www.theguardian.com/environment/2015/oct/26/morocco-poised-to-become-a-solar-superpower-with-launch-of-desert-mega-project.

31 Hamdo, Ahmad Hajj. “With Diesel Scarce, Syrians Turn to Solar Power as an Emerging Energy Option” Syria Deeply. 28 November 2014. Accessed 16 March 2016. http://www.syriadeeply.org/articles/2014/11/6439/diesel-scarce-syrians-turn-solar-power-emerging-energy-option/

Center for Conflict,
Negotiation and Recovery

School of Public Policy

Central European University

Nador u. 9 | 1051 Budapest | Hungary Phone:
+36.1.327.3000 | ext. 2614

aleppo@spp.ceu.edu