IIASA Policy Brief

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Expanding Solar Energy in North Africa to Achieve Climate Targets

This briefing identifies the opportunities, risks, and challenges associated with efforts to expand solar energy capacity in North Africa to the point where it can make a significant contribution toward achieving emissions reductions targets.

Summary

- Recent policies in Europe and the United States have led to a surge of development in concentrating solar power (CSP), with generating capacity due to expand by a factor of ten over the next five years. CSP with thermal storage is one of the few renewable supply options that can provide base-load and dispatchable power. The economic potential of CSP from desert regions is larger than current global energy demand; this means that CSP could replace a large fraction of current thermal power generation from fossil fuels.

- There have been several recent government and private sector initiatives to couple the expansion of CSP capacity in North Africa with the development of high-voltage direct current (HVDC) transmission lines to Europe. The European Renewable Energy Directive (2009/28/EC) would allow such imported electricity to contribute to member states' 2020 emissions reductions targets, but there is no specific policy in place to establish the financial and regulatory framework for any such development.

- This study addresses the opportunities and risks associated with European—North African cooperation on CSP development, as well as the challenges that a policy framework must overcome.
  - **Opportunities** CSP development in North Africa offers not only an affordable option to help European countries achieve 2020 renewable energy targets without sacrificing system reliability, but also the possibility of establishing a lower-cost alternative to conventional power generation that could help achieve global 2050 emissions reduction targets.
  - **Risks** CSP development in North Africa is unlikely to increase Europe's energy import dependency or impose new risks of large-scale system blackouts in the event of hostile state or terrorist activities. It may, however, be blocked by potentially prohibitive financial risks for project developers associated with the business and investment climate in North Africa.
  - **Challenges** To stimulate the development of CSP and transmission capacity, policies must address the barriers to siting international transmission lines in Europe, the financial requirements of project and supply chain developers, and the needs of North African countries to provide increased energy access and sustainable job growth to their citizens.

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PIK

What is Concentrating Solar Power?

Concentrating solar power (CSP) technologies use mirrors to reflect and concentrate sunlight onto receivers that attain very high temperatures. This thermal energy can then be used to produce electricity via a steam turbine or heat engine driving a generator. It is also practical to store the heat in insulated containers, and use it to generate electricity hours or even days later. CSP with thermal storage is one of the few renewable supply options that can provide power that is both base-load (the amount required to meet minimum demands based on reasonable expectations of customer requirements) and dispatchable (can be turned on or off, on demand).

CSP technology has been around for decades but, after a brief spurt of investment in the late 1980s, has seen no growth—probably because it works best in desert climates and, in the last decade, most motivation for renewable energy has been from northern countries. Suddenly CSP is exciting again, being perhaps the only renewable technology that can be scaled up enough to satisfy a large share of global energy demand. Unlike photovoltaic and wind, it is not intermittent; however, long transmission lines are needed from unpopulated desert locations to populated places.

Introduction

In November 2008 the International Institute for Applied Systems Analysis (IIASA), together with the Potsdam Institute for Climate Impact Research (PIK) and the European Climate Forum, hosted a three-day expert workshop on the political, policy, and financial challenges associated with developing large-scale concentrating solar power (CSP) in North Africa and the transmission capacity required to export a large fraction of that power to Europe. Participants in the workshop included European and North African academic researchers, project developers, policymakers, and representatives from development organizations. Researchers at IIASA and PIK used the conclusions from the workshop to guide a set of focused empirical and modeling analyses. The results, which have been published in a number of peer reviewed journals, highlight three sets of issues.

Opportunities

To examine the opportunities of CSP development in North Africa, IIASA and PIK researchers developed the Mediterranean Area Renewable Generation Estimator (MARGE), an open-access model that allows rapid estimation of the costs associated with different geographically specific CSP development scenarios. MARGE is based on the most up-to-date industry data on CSP and high-voltage direct current (HVDC) transmission. The researchers have used MARGE to examine the opportunity for CSP to become cost-competitive with coal- and gas-fired power plants (Figure 1), with several important results:

- Using baseline assumptions about the rate of technological learning, financial returns on investment, geographical siting, and competing technology costs, the researchers first estimated that total discounted investments of €210 billion in CSP and HVDC would be required to lower the cost of CSP-generated power to below that of domestic power from coal and gas. To make these investments attractive, government or consumer subsidies totaling €65 billion would be required. These would cover the difference in levelized electricity costs between CSP and the least-cost alternative, which was assumed to be coal without carbon capture and storage, and could be generated through national quotas, the European Emissions Trading System, and a feed-in tariff. Assuming rates of growth consistent with observed growth rates for wind, cost parity would be reached by 2035.

- The investment costs, subsidies required, and time to cost parity could all be substantially less, given alternative but plausible assumptions about future development. Expanding R&D spending to accelerate the pace of technological learning and offering loan guarantees to reduce the cost of project financing could reduce the total amount of subsidies required to €10 billion. Together with removing some of the existing subsidies for fossil fuels, these would accelerate the point of cost parity to 2020. Doing so would enable developing countries expanding their power sectors to shift new investment from fossil fuels to CSP at no additional cost, even assuming similar needs for long-distance transmission.

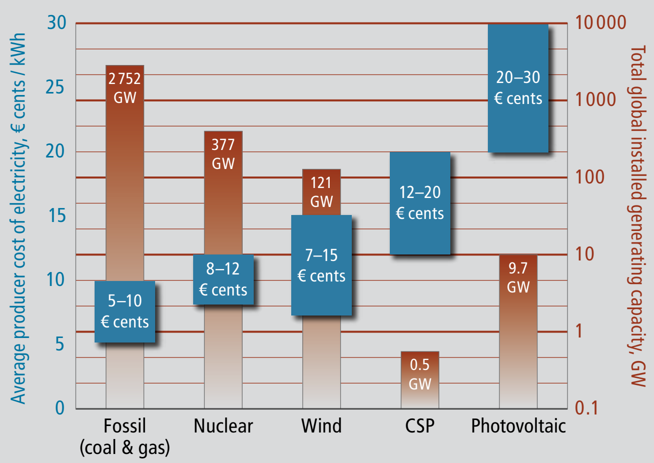
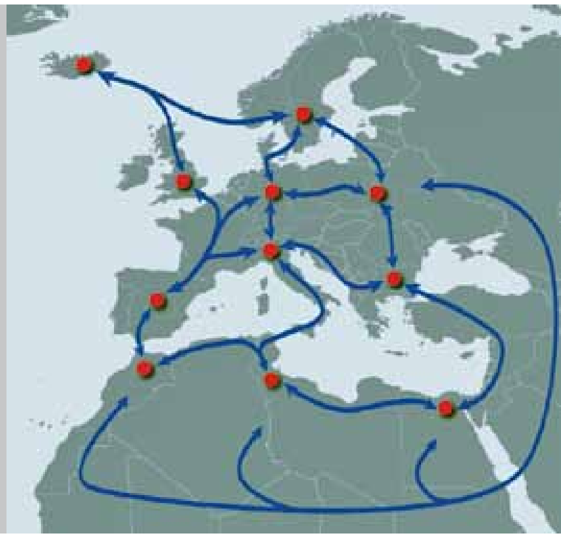


Figure 1
The cost of producing electricity by various technologies currently ranges from 5–10 € cents / KWh for fossil fuels to 20–30 € cents / KWh for photovoltaic (PV) (blue boxes). The total global installed generating capacity of the various technologies ranges from 0.5 GW for CSP to 2752 GW for fossil fuels (red bars). As an empirically-based rule of thumb, every time the total installed capacity for a given technology doubles, the costs fall by about 10–15% on account of learning and economies of scale. This suggests that to become competitive with fossil fuels, CSP would have to grow to be about half the capacity of what wind is now. IIASA modeling suggests that this could occur in as few as ten years, and would require total subsidies ranging from € 10–65 billion to leverage private sector investment. For either nuclear or PV to become cost competitive, they would have to grow to be larger than the current fossil fuel capacity—a much greater amount. These are rough calculations, and technological breakthroughs could make a big difference.
Source: IIASA / *Data sources*: IEA, US DoE, NREL

Regional transmission lines across Europe and the Mediterranean are essential to carry power. This schematic map suggests the need for a network of point-to-point high voltage direct current (HVDC) lines connecting hubs of power supply and demand. It is essential to plan these at the regional scale; this will require a shift in regulation, as currently grid planning occurs almost exclusively at the national level in Europe. *Source*: Potsdam Institute for Climate Impact Research (PIK)



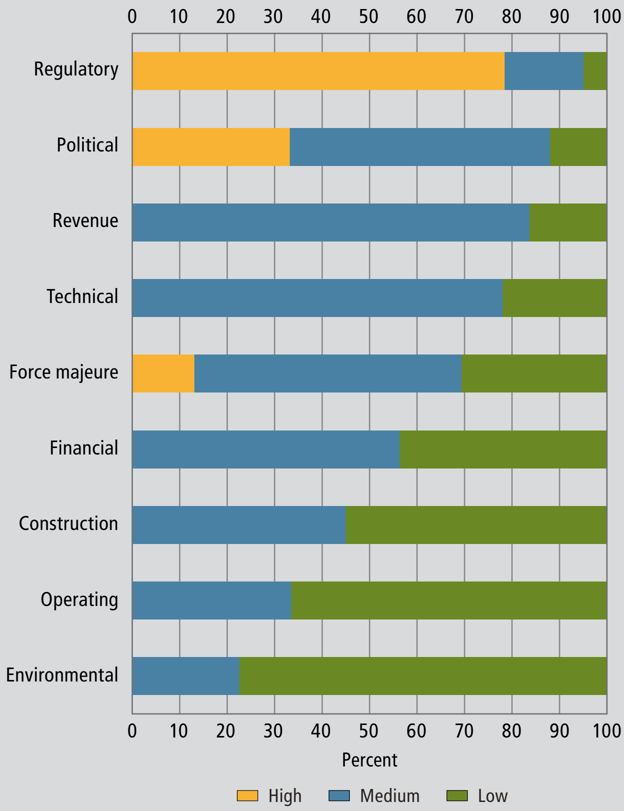


Figure 2
The risks identified as "of concern" to leading stakeholders involved in considering concentrating solar power investments in North Africa. Eighteen stakeholders interviewed in spring 2009. *Source*: IIASA

Risks

In discussions with stakeholders, the risks associated with large-scale CSP development in North Africa emerges as a key concern. From a European perspective, these risks fall into two categories: the risks to European countries and their energy security associated with importing electricity from North Africa; and the risks to European firms and project developers doing business in North Africa.

Risks to European countries Analysis of the energy security concerns shows these risks to be manageable, for several reasons. First, EU member states currently import 54 percent of the energy they consume, mainly in the form of oil for the transportation sector, and coal, gas, and uranium for the power sector. CSP development in North Africa would be unlikely to create additional import dependency because they would displace existing imports. Second, the European power sector operates with significant generating capacity reserves. In the event of a supply interruption, these could be brought online almost immediately and maintained indefinitely, albeit at some cost. Model results suggest that it would be nearly impossible for North Africa states, much less terrorist organizations, to interrupt a sufficient fraction of supply to exceed these reserves. Third, unlike fossil fuels and uranium, an interruption in the supply of electricity would represent an unrecoverable loss of revenue for supply countries, because electricity cannot be stored. Model results suggest that the lost revenues would harm exporting countries far more than the supply interruption would harm Europe.

Risks to European firms To examine the risks facing CSP project developers in North Africa, IIASA researchers conducted extensive interviews with a broad range of stakeholders (Figure 2). These revealed that the risks associated with terrorism and deliberate state action are not of major concern to them. However, the risks associated with changing regulatory environments, as well as slow and unpredictable permitting processes, are of major concern. Indeed, these have largely prevented the private sector from taking the lead on renewable energy developments in the region. A number of policies and programs are available to address both the causes and the consequences of the bureaucratic challenges in the region.

Policy challenges

Policy cooperation at the regional level will be required to stimulate investment in CSP and reap the benefits the technology offers. Cooperation needs to address three urgent challenges:

(1) European policymakers must address the challenge of planning and siting international HVDC lines. Currently, grid planning and development takes place almost exclusively at the national level, and there is no agency charged with addressing European-wide transmission issues. This will have to change if HVDC lines are to enter Europe from the south, carry power across the continent to large demand centers, and balance loads from intermittent generators (map, page top).

IIASA Policy Briefs present the latest research for policymakers from IIASA—an international, interdisciplinary research institute sponsored by scientific organizations in Africa, the Americas, Asia, and Europe. This brief, written by IIASA's Anthony Patt, is based on collaborative research between IIASA(1) and PIK, the Postdam Institute for Climate Impact Research(2) (Anthony Patt,[1] Antonella Battaglini,[2] Giulia Carboni,[2] Armin Haas,[2] Nadejda Komendantova,[1] Johan Lilliestam,[1,2] Keith Williges[1]). The views expressed herein are those of the researchers and not necessarily those of IIASA, PIK, or the organizations that fund the Institutes' research.

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A concentrating solar power station.
Source*: Abengoa Solar*

(2) Policies need to create the financial incentives for project and supply chain developers. Existing renewable support mechanisms in Europe operate at the national level, and in most cases do not apply to electricity imported from elsewhere. There is a need for international cooperation, and ideally EU leadership, on the support schemes for CSP developments in North Africa. The cost of CSP support will be markedly reduced if there are also policies in place to reduce investor risk. The support schemes will have to be stable enough to stimulate investments in expanding supply chains.

(3) It is essential to ensure that CSP projects in North Africa benefit North Africans. They can do so through two major channels. First, they can leverage European investment and the Clean Development Mechanism to expand generating capacity for local markets at affordable prices. Second, they can generate direct and indirect employment in project planning and construction, operation and maintenance, and equipment supply. But neither of these benefits is a foregone conclusion of CSP expansion: both are sensitive to the contracts negotiated for individual projects and will hence require regional policies to set the baselines from such negotiations, and these to be supplemented with appropriate capacity development and the terms of technology transfer.

Conclusions

It is not only possible to expand solar energy development in North Africa to achieve regional emissions reductions targets, but it also makes sense to do so. However, there is an urgent need for regional policies to overcome the technical challenge of transmitting large amounts of power into and across Europe, to stimulate private sector investment, and to maximize the benefits that North Africans receive from this development.

Further information

This Policy Brief is based on research funded by the German Federal Ministry for Education and Research, and the European Climate Foundation. At the time of writing, the results can be found in the following papers:

- Battaglini A, Lilliestam J, Haas A & Patt A (2009). Development of SuperSmart Grids for a more efficient utilization of electricity from renewable sources. *Journal of Cleaner Production* 17:911–918.
- Patt A (2009). Beyond conventional thinking: mitigation and the real opportunities for developing countries. *Climate & Development* 1:107–110.
- Patt A (in press). Effective regional energy governance—not global environmental governance—is what we need right now for climate change. Published online November 2009 at *Global Environmental Change*.
- Komendantova N, Patt A, Barras L & Battaglini A (in press). Perception of risks in renewable energy projects: The case of concentrated solar power in North Africa. Accepted for publication at *Energy Policy*.
- Williges K, Lilliestam J & Patt A (in review). Making concentrated solar power competitive with coal: The costs of a European feed-in tariff. Submitted September 2009 to *Energy Policy*.
- Komendantova N, Patt A & Williges K (in review). Perceived risk associated with solar power investment in North Africa, the ways to reduce it, and the benefits of doing so. Submitted November 2009 as part of a proposed special issue of *Energy Policy*.

For more information, or to request reprints of any of the above articles, please contact Anthony Patt: patt@iiasa.ac.at

Access to the MARGE model can be found at: www.iiasa.ac.at/Research/RAV

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