Concentrating solar power: its potential contribution to a sustainable energy future

European Academies Science Advisory Council

The European Union (EU) has established challenging targets for making a transition to a sustainable energy system in Europe, including that the EU's electricity supply should achieve essentially zero emissions of greenhouse gases by 2050. Similarly, countries in the Middle East and North Africa (the MENA region) are aiming to develop their economies, pointing to the need for the associated development of energy infrastructures which are sustainable, particularly in the context of international initiatives to tackle climate change.

Major developments will be needed in renewable energy technologies to enable these aims to be achieved. One such technology is concentrating solar power (CSP) in which a high-temperature heat source is created by concentrating the sun's rays to produce electricity in a thermodynamic cycle.

The European Academies Science Advisory Council (EASAC) has published a report that presents the results of a study examining the potential of CSP to contribute to meeting the desired energy system transitions in Europe and the MENA region, and to consider the scientific, technical and economic developments that will be required to enable that potential to be realised. The study has confirmed that the solar resource and technological potential are such that CSP based in Southern Europe and the MENA region could make a substantial contribution to meeting future energy needs.

There are various CSP technologies with different advantages and disadvantages, and CSP plants need to be designed to optimally meet local and regional conditions. Worldwide in 2011, 1.3 gigawatts (GW) of CSP were operating and a further 2.3 GW were under construction. Currently, base-load electricity generated by CSP plants located where there are good solar resources costs two to three times that from existing fossil-based technologies without carbon capture and storage. CSP generation costs are on a par with photovoltaics and offshore wind, but are significantly more expensive than onshore wind.

Provided that commercial deployments of CSP plants continue to grow, and that these deployments are associated with sustained research, development and demonstration programmes, CSP generating cost reductions of 50–60% may reasonably be expected over the next 10–15 years. Allowing for some escalation in fossil fuel prices and incorporation of the costs of CO_2 emissions in fossil generation costs (through carbon pricing mechanisms and/or requirements to install carbon capture and storage), it is anticipated that CSP should become cost competitive with base-load fossil-based generation at some point between 2020 and 2030. In specific locations with good solar resources this point may be reached earlier.

CSP plants that incorporate thermal storage and/or supplementary firing offer additional potential benefits beyond the value of the kilowatt-hours that they generate, as they can provide dispatchable power, helping the grid operator to reliably match supply and demand, and maintain grid stability. The value of this capability is context specific, but increases as the proportion of electricity generated by variable renewable sources such as wind and photovoltaics increases. CSP with storage may therefore, in future, offer a cost-effective way of enabling the incorporation of substantial contributions of variable renewable sources in electricity systems.

Environmental impacts of CSP plants are generally low, and may be expected to improve further compared with fossil-fired technologies over time given the relatively early stage of development of CSP. Although the construction of CSP plants is more material intensive than fossil-fired plants, the required materials are mainly commonly available, and readily recyclable: materials such as steel, concrete and glass. Given the likely positioning of CSP plants in arid areas, their use of water, particularly for cooling, is an issue pointing to the need to improve the performance of air-cooling systems.

The solar resource in Southern Europe is such that CSP could provide a useful contribution to achieving Europe's aim of a zero-carbon electricity system by 2050. Solar resources in the MENA region are even better, and far larger. Once CSP achieves cost parity with fossil-fired generation, these resources have the potential to transform the system of electricity generation in Europe and the MENA region.

Around half of the anticipated reductions in CSP generating costs are expected to come from technology developments, and the other half from economies of scale and volume production. Well-designed incentive schemes will be needed, which reflect the real, time-varying value of generation so that CSP plants are appropriately designed, and which effectively drive research and development activities. The total amount of incentive payments that will be needed to achieve cost parity will depend crucially on how quickly costs reduce as installed capacity increases. Incentive schemes need to ensure that cost data are made available so that the learning rate, and its underlying drivers, can be established and monitored, and consequently energy strategies and incentive schemes can be adjusted as appropriate. Substantial investments will also be needed in transmission infrastructure, including high voltage direct current links between the MENA region and Europe, if substantial quantities of CSP electricity are to be exported from MENA countries to Europe.

The development of CSP in the MENA region is a potentially significant component of initiatives to support low-carbon economic development and political progress in the region as reflected in the Barcelona Process, the Deauville Partnership, etc. CSP technologies (unlike some other renewable energy technologies) lend themselves to high levels of local-deliverables, well-matched to the capabilities of the workforce and industries in the region.

Given the rapidly increasing demand for electricity in MENA countries, much of the electricity generated by CSP plants in the MENA region over the short to medium timescale may, and should, be expected to be used locally rather than exported to Europe, thus avoiding the construction of fossil-fired capacity in the MENA region. Financing schemes, and associated political agreements between the EU and MENA countries, will be needed to enable these short- to medium-timescale developments. Without financial commitment in the order of billions of euros from Europe, renewable energy technologies including CSP are unlikely to develop quickly in the MENA region.

The challenge is to take a coordinated approach, simultaneously addressing the different bottlenecks (investment protection, energy policy incentives, R&D, etc.), and to identify options which lower the barriers to entry for other actors. For this purpose, a transformation process should be defined that addresses the technical, political and socio-economic factors necessary to achieve integration of EU and MENA energy systems and to strengthen the implementation of renewable options in the MENA region. Co-funding and co-financing options for CSP in the MENA region should be developed by the EU at a substantial scale as part of its neighbourhood policy.

Incentive schemes in Europe and MENA countries should reflect the true value of electricity to the grid, effectively drive R&D, and ensure transparency of cost data. R&D should be funded at EU and national levels to complement commercially funded research. Funding schemes should ensure that market realities are strong drivers of R&D, and should ensure that new technologies can progress rapidly from the laboratory, through pilot and demonstration scales, to commercial application.

Further system simulation studies should be undertaken to look at interaction effects for different shares of renewable energy sources at EU, MENA and EU–MENA levels of power system integration. Understanding from these studies, together with data on the learning rates of CSP and photovoltaics technologies, should be used to guide the development of the optimal mix to harness solar resources.

Capacity-building initiatives should be put in place to support sustainable growth of the necessary technological skills in the relevant countries and regions. Such initiatives may include developing international networks of universities and industrial companies, and programmes for technology transfer from research to industry.

The full report is available at www.easac.eu.

About EASAC

EASAC – the European Academies Science Advisory Council – is formed by the national science academies of the EU Member States to enable them to collaborate with each other in providing advice to European policy-makers. It thus provides a means for the collective voice of European science to be heard.

Its mission reflects the view of academies that science is central to many aspects of modern life and that an appreciation of the scientific dimension is a pre-requisite to wise policy-making. This view already underpins the work of many academies at national level. With the growing importance of the European Union as an arena for policy, academies recognise that the scope of their advisory functions needs to extend beyond the national to cover also the European level. Here it is often the case that a trans-European grouping can be more effective than a body from a single country. The academies of Europe have therefore formed EASAC so that they can speak with a common voice with the goal of building science into policy at EU level.

Through EASAC, the academies work together to provide independent, expert, evidence-based advice about the scientific aspects of public policy to those who make or influence policy within the European institutions. Drawing on the memberships and networks of the academies, EASAC accesses the best of European science in carrying out its work. Its views are vigorously independent of commercial or political bias, and it is open and transparent in its processes. EASAC aims to deliver advice that is comprehensible, relevant and timely.

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