Swap solar energy from the Middle East and North Africa (MENA) for scientific equipment or access to facilities in Europe. Boost the scientific level in the region through exchanges and collaboration. Establish in Cairo a joint European–MENA solar energy center for research and implementation of relevant technologies. Power the region’s scientific facilities with solar energy.

Those are among the ideas that some 250 scientists, policymakers, and others came up with in May at the Solar Energy for Science symposium held at DESY, the Electron Synchrotron laboratory in Hamburg, Germany. The atmosphere at the symposium “was really unbelievable. It was a festival,” says DESY director Helmut Dosch. “You tend to get drunk from the ideas, but we will have to find out what is realistic.”

The symposium was the inauguration of a scientific initiative inspired by and connected to Desertec, a foundation working to realize its founder’s dream: harnessing solar energy from deserts to supply much of the world’s energy demands.

Clean-energy dreams

Gerhard Knies, a retired DESY physicist, was the driving force in starting Desertec in 2009 after discovering that “within six hours deserts receive more energy from the sun than humankind consumes within a year,” as the foundation’s website proclaims (see the box on page 22). He later launched the Desertec Industrial Initiative (Dii), a coalition of businesses that works toward creating the necessary political, social, legal, and financial conditions to make solar energy a significant part of the energy equation. Dii aims “to pave the way for private business,” says Knies. “It’s not a company to build power plants.”

Early estimates put a total cost of about €400 billion ($580 billion) on the infrastructure required for solar energy from MENA to satisfy 15% of Europe’s energy needs by 2050. If Knies is right, “the transfer from fossil fuel to renewable energy will become the biggest business of the future.”

For its part, DESY runs on roughly 200 gigawatt-hours per year. “With our current energy mix, we are responsible for 100 000 tons of carbon dioxide per year,” says Dosch. “The key question is, How could a national lab like DESY help get [the Desertec vision] off the ground? How can we contribute to getting cleaner energy?”

The Solar Energy for Science initiative grew out of an evening of brainstorming with Knies, says Dosch. “The idea came up that [research facilities] could be a pathfinder for developing relations to North African countries on the scientific level. You build trust and joint scientific and technical projects.” Such projects could be related to solar energy, but they would not have to be. Knies adds, “I prefer to say ‘science energy for solar.’ I think science should be the driving force in building a sustainable world.” Support for achieving a robust supply of renewable energy gained momentum with the late-May announcements that Switzerland and Germany would phase out their nations’ nuclear power plants in the wake of the Fukushima partial nuclear meltdown.

Not surprisingly, most of the ideas from the symposium are pie in the sky at this stage. One concrete action was the signing of an agreement by DESY and SESAME, the Middle East synchrotron light source under construction in Jordan, to strengthen scientific cooperation and promote renewable energy in MENA “towards a vision... of shared interests in energy, science and climate protection.” And several future meetings were set. In October, strategies for creating a sustainable energy supply will be discussed at a meeting on energy-management issues at large research facilities. People involved in Solar Energy for Science will meet as part of a larger Dii conference in Cairo in November. And late next year, when it holds the rotating European Commission (EC) presidency, Cyprus will host a follow-up symposium.

Pilot projects

Concentrated solar power (CSP) is the favored technology for the Desertec vision of collecting solar energy in MENA deserts (see cover photo). With CSP, sunlight is focused to heat a fluid. Molten salt, for example, can be heated to 500 °C or more, and fluids can be piped to other locations. The energy is stored as a hot fluid and converted to electricity via steam engines. “This is a chance to set up a system that supplies energy on demand, not just when the sun is shining,” says Robert Pitz-Paal, head of solar-energy research within the German Aerospace Center, which co-organized the May symposium. That capability is the main difference between CSP and photovoltaics, for which the incident solar energy is

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Scientists help make deserts into solar-energy hubs

Enthusiasm is high for collecting solar energy in the Middle East and North Africa, with some to be exported to Europe. But doing so requires overcoming political, social, legal, technical, and financial obstacles.
immediately converted to electricity. To send solar energy from the Sahara to Europe, though, high-voltage DC cables would need to be installed under the Mediterranean Sea.

Construction of a 500-MW solar energy project in Morocco is set to begin in 2013. That project, says Knies, “will not have the Desertec label at its gate, but we paved the way. The work of the foundation is to convince decision makers [to build solar energy plants] and to help them get the money.” Egypt has a 20-MW solar power plant, and work is starting this summer on a 1-MW CSP pilot plant whose energy output will be used for water desalination. With its €22 million contribution, the EC is paying the lion’s share of the pilot plant’s cost. Egyptian vice minister of science and technology Maged Al-Sherbiny says, “This is a research facility, but you can look at problems—with tubes [holding molten salt], dust, wind, mirrors, things of this kind. It allows you to enhance materials.” Although the project predates Solar Energy for Science, the two initiatives will form ties. “The reason for establishing the pilot plant is to encourage industry,” says Al-Sherbiny. “If this happens, solar energy will meet local energy needs and eventually can also be transported to Europe.”

“A win-win situation”

Amid the enthusiasm for solar energy, concerns crop up about the Desertec dream smacking of imperialism. Samir Romdhane, for example, says that in Tunisia, where he is a physicist at the Faculty of Sciences of Bizerte, “Our main work is on photovoltaic technology. No industry in Tunisia can produce anything for this [CSP] project, so it looks like all parts will be imported.” But, he adds, “if we can develop projects in which Tunisian industries and researchers can do something, then I think it will be a good thing.”

Odeh Al-Jayyousi, a water engineer and West Asia regional director of the International Union for Conservation of Nature, says his organization and others in Jordan “are promoting Desertec as the future big idea that can transform our economy, energy, and poverty.” Given the region’s expanses of desert, he says, “We can reach a win-win situation, where we export renewable energy, localize green technology, provide green jobs, and address climate change risks.” Many MENA countries, Al-Jayyousi says, have strategic policy goals to get 10–20% of their energy from renewable sources in the next 10 years.

Scientists can offer “cooperation and exchange with institutions in MENA, renewable sources in the next 10 years. Goals to get 10–20% of their energy from Jayyousi says, have strategic policy risks.” Many MENA countries, Al-Sherbiny says, have strategic policy green jobs, and address climate change. “We can reach a win-win situation, where we export renewable energy, localize green technology, provide green jobs, and address climate change risks.” Many MENA countries, Al-Jayyousi says, have strategic policy goals to get 10–20% of their energy from renewable sources in the next 10 years.

Scientists can offer “cooperation and exchange with institutions in MENA, proportionately. The Desertec Industrial Initiative (Dii) followed. A coalition of industry shareholders, including Deutsche Bank, Siemens, and the reinsurance giant Munich Re, Dii aims to smooth the way for building solar energy plants in the deserts to power both the host regions and Europe; a Saudi Arabian company is the latest to join. “There are a number of obstacles that make it different from normal business,” Knies says. The Dii’s goal is by late 2012 to create conditions that enable private business to build solar power plants in MENA and transmission lines to Europe. The initiative’s focus includes creating legal provisions and securing funding from European and MENA governments. In addition to the foundation and Dii, a third entity is the Desertec University Network, which promotes scientific exchange and knowledge dissemination to build up technological know-how among MENA countries.

Knies says that people in MENA countries “are much more eager to get this project going than are the Europeans.” That stems, he says, from a political stance in the European Union that “renewable energy should make the EU independent of other countries.” But, says Knies, “I had the opposite approach. Only if you consider the rest of the world your enemy do you need independence.”

And from the MENA point of view, solar energy is something they “could do better than Europe. They have a hidden asset, the deserts,” Knies says. “There is no competition for other land use, and it’s almost never cloudy.” Right now, he continues, “people are unemployed, there are not jobs, and there is exploding population. Science has to empower [those countries] to make a product.” Even if MENA countries remain unstable and unreliable, he adds, “they will continue to be our neighbors, so we better help them to have a transformation, and also transform the relations to be cooperative instead of suspicious, defensive, and offensive.”

The EU’s reluctance has eased in the past several years, Knies says, noting that in 2007 Jordan’s Hassan helped gain support for the Desertec mission with a white paper he presented to the European Parliament. And even with many MENA countries in political upheaval, “we cannot wait to have good politics everywhere to save the planet.”
and let them participate in knowledge,” says Frank Lehner, the DESY physicist who is coordinating Solar Energy for Science. “How can we create new schemes between institutions and also promote and foster deployment of renewable energies in the region? We see scientific cooperation as a key instrument for capacity building—so that people in MENA are able to get into R&D in solar energy and innovation to build their own plants. This is the idea of Solar Energy for Science.” In the longer term, Lehner says, “we can imagine that research infrastructures in Europe could trade a physical transfer of energy from the desert and in return offer participation in our facilities. Why not push European infrastructures as the first customers for solar energy?”

Toni Feder

**Shale-gas extraction faces growing public and regulatory challenges**

Over the past decade, advances in drilling technology for natural-gas wells have opened up a vast new domestic source of energy that had been considered too expensive to exploit. But environmental concerns with the process used to recover shale gas are slowing its development in the Northeast. The US possesses 827 trillion cubic feet (1 tcf = 28 × 10¹² L) of potential gas resources in shale deposits, according to the Energy Information Administration, part of the Department of Energy; that amount is double the EIA estimate of just one year ago. The agency now estimates the US has enough gas from all sources to meet domestic demand for 110 years at 2009 consumption levels. Production of shale gas is booming; US output grew at an average annual rate of 48% from 2006 to 2010. By 2035, the EIA projects, shale gas will account for 35% of total domestic gas production, compared with 14% in 2009.

Although it’s long been known that shale formations contain abundant natural gas, it took development of a new type of unconventional recovery technique known as hydraulic fracturing, or fracking, to make extracting the gas economically viable. In the fracking process, a well is drilled horizontally through shale formations, which generally lie 1000 meters or more beneath the surface. Next, explosives are used to blow holes through the well casing. Then a fluid consisting mainly of water and sand is injected down the well at very high pressures, causing the shale to fracture. Once pressure is released, the fracturing fluid flows back to the surface, and gas from the shale flows into the well.

Shale-gas fracking was developed in the early 2000s in the Barnett shale formation beneath northern Texas and Oklahoma. More recently, the technology is being used in exploiting gas in the Marcellus shale formation, which extends from southern New York across Pennsylvania and into western Maryland, West Virginia, and eastern Ohio. Two-thirds of Pennsylvania lies atop the Marcellus formation, and more than 3000 shale-gas wells have been drilled there.

### Injection wells and recycling

Although the fracking process is essentially the same in the Barnett and Marcellus shales, the disposal of wastewater generated in fracking differs greatly between the two. In Texas, shale-gas drillers can inject their waste into some of the thousands of oil and gas waste-injection wells located in and near the Barnett formation. Nationwide, there are more than 144,000 waste-injection wells, also known as Class 2 wells, according to the Environmental Protection Agency. More than 2 billion gallons of waste, mostly brine, from oil and gas drilling and production are injected into those wells each day. Pennsylvania has only a handful of Class 2 wells, says Anthony Ingraffea, a Cornell University engineer and fracking expert.

New York State has no disposal wells. In sharp contrast to its neighbor to the south, New York has yet to permit a single shale-gas well that uses the fracking technique. Drilling won’t begin there until an environmental impact assessment is finalized. The assessment process began in 2009, and Governor Andrew Cuomo (D) recently ordered the state’s environment department to finish it by 1 July, when a moratorium he issued on shale drilling is due to expire. Although the state’s Democrat-controlled assembly voted to extend the ban by nearly another year, the Republican-controlled senate is unlikely to concur.

The lack of injection wells has forced Marcellus shale drillers to find other means for disposing of up to 7 million gallons of wastewater generated at each well. Although fracking fluids are more than 99% water and sand, they also contain a number of chemicals, including some that are toxic at the parts-per-billion level, such as benzene, antimicrobial agents, and corrosion inhibitors.

Shale-gas drillers consider the composition of their fracking fluids to be proprietary. But with increasing pressure for disclosure from the public and environmental groups, big Marcellus players such as Chesapeake Energy and Devon Energy have recently begun to make the ingredients public. The state legislature in Texas passed a bill in May to mandate disclosure of the fluid ingredients. Democrats on the federal House Energy and Commerce Committee released a report in April that identified 29 chemicals that are either known or possible carcinogens and are subject to EPA regulation under the Clean Water Act. Oil and gas fracking, however, was exempted from the act in 2005 by a provision tucked into the Energy Policy Act.

### Spills and emissions

Environmental groups clamoring for federal regulation point to uneven enforcement by state agencies and to spills and other environmental incidents at drilling sites and in transport of waste and chemicals. Public records show that 1200 violations of environmental regulations occurred at gas wells in Pennsylvania last year, according to the advocacy group Clean Water Action. In April, that state’s governor Tom Corbett (R) asked well operators to voluntarily refrain from disposing of their fracking wastewater at municipal water treatment plants, which cannot remove bromides and other dissolved solids from the fluid. Speaking to a meeting of the Geological Society of America in March, Pennsylvania State University researcher David Yoxtheimer estimated that two-thirds of wastewater generated from fracking operations in Pennsylvania (44 million of 65 million gallons) had been recycled during a two-year period ending in May 2010.

Chesapeake Energy in May agreed to pay a record $1.1 million after state regulators concluded that the company’s improperly drilled gas wells had allowed gas from shallow,