1. The DESERTEC Concept

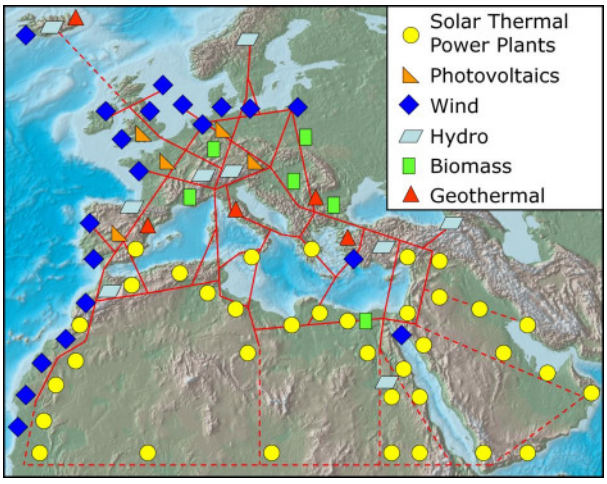
By far the largest, technically accessible source of energy on the planet is to be found in the deserts around the equatorial regions of the earth. The **DESERTEC Concept** is designed to bring deserts and existing technology into service to improve global security of energy, water and the climate. To this end we propose **Eu**rope, the **M**iddle **E**ast and **N**orth **A**frica (**EU-MENA**) begin to cooperate in the production of electricity and desalinated water using concentrating solar thermal power and wind turbines in the MENA deserts. These technologies can meet the growing demands for power production and seawater desalination in the MENA region, and produce clean electrical power that can be transmitted via **H**igh **V**oltage **D**irect **C**urrent (**HVDC**) transmission lines with relatively little transmission loss to Europe (10-15%). From a political point of view, implementing DESERTEC in countries like Australia, China, India and the USA, should be even easier.

The technologies necessary to realize the DESERTEC Concept have already been developed and some of them have been **in use for decades**. Based on satellite data, several studies by the German Aerospace Center (**DLR**) confirm the availability of solar energy. The developments in energy provision and the climate situation gives added urgency to implementing this Concept. All that is needed now is the political will and the right framework of incentives.

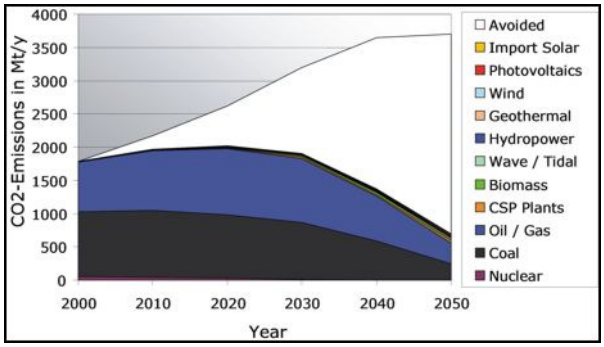
2. The TREC Network

The **T**rans-Mediterranean **R**enewable **E**nergy **C**ooperation (**TREC**) was founded in 2003 by The Club of Rome, the Hamburg Climate Protection Foundation and the National Energy Research Center of Jordan (**NERC**). TREC has developed the **DESERTEC Concept** and completed the necessary research in cooperation with the German Aerospace Center (**DLR**). TREC is now making this Concept a reality in cooperation with people in politics, industry and the world of finance. A **DESERTEC Foundation** to strengthen these activities is being formed.

The core of TREC is an **international network** of scientists, politicians and other experts in the development and implementation of renewable forms of energy. The members of TREC, approximately 60 in number (including *His Royal Highness Prince Hassan bin Talal of Jordan*), are in regular contact with national governments and private investors, with the aim of communicating the benefits that may be obtained from the cooperative use of solar and wind energy and promoting specific projects in this field. Regional DESERTEC networks disseminate the ideas in their home countries.



Euro-Supergrid with a EU-MENA-Connection: Sketch of possible infrastructure for a sustainable supply of power to **EU-MENA**.



CO2-emissions from electricity generation expected for all the EU-MENA countries (in millions of tons per year) assuming vigorous efforts to increase efficiency.
Upper curve: With an electricity generation mix equivalent to that of the year 2000.
Second curve from top: For the scenario described in the TRANS-CSP study with emissions reduced by the use of renewable sources and the transmission of clean power from MENA to Europe.

TREC

Clean Power from Deserts
Trans-Mediterranean
Renewable Energy Cooperation
An Initiative of The Club of Rome

THE CLUB OF ROME

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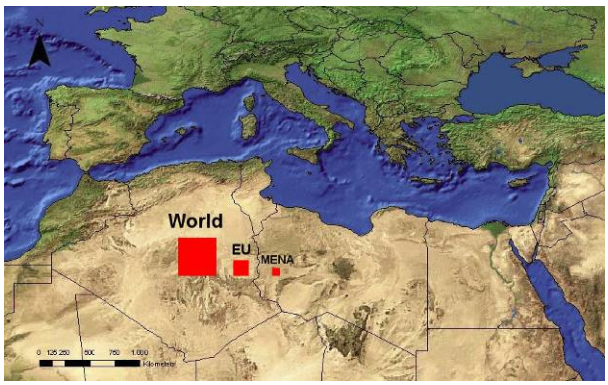
3. Three Studies by DLR

TREC was founded with the goal of providing clean, cost efficient energy for EU-MENA as soon as possible and based on economic cooperation between the countries in the region. TREC sees the **power from deserts** as a **supplement** to European sources of renewable energy and as a means of speeding up the process of cutting European emissions of CO_2 and increasing the security of European energy supplies. For people in the Middle East and North Africa (**MENA**) this would mean plentiful supplies of clean electricity, jobs, earnings, an improved infrastructure, potential for the desalination of sea water, and several potential benefits (e.g. for agriculture) from the shade provided by solar (fresnel) collectors.

TREC has been involved in the conduct of **three studies** which have evaluated the potential of renewables in MENA, the expected needs for water and power in EU-MENA between now and 2050 and issues relating to the construction of an **electricity transmission grid** connecting the EU and MENA (**EU-MENA-Connection**). Those three studies were commissioned by the German Federal Ministry for the Environment, Nature Conversation and Nuclear Safety (BMU) with the **German Aerospace Center (DLR)** taking the lead. These '**MED-CSP**' and '**TRANS-CSP**' studies were conducted between 2004 and 2006. The '**AQUA-CSP**' study covering aspects of solar desalination was completed towards the end of 2007.

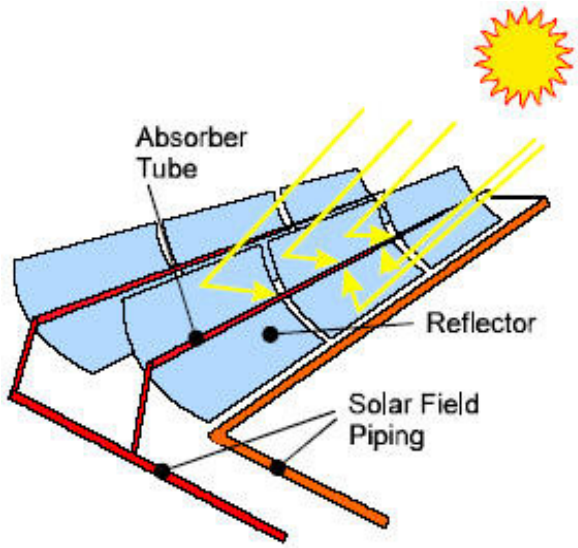
Satellite-based studies by the German Aerospace Center (DLR) have shown that, by using **less than 0.3% of the entire desert area** of the MENA region, enough electricity and desalinated seawater can be produced to meet the growing needs of these countries and of Europe. Power generation from wind energy is particularly attractive in Morocco and in areas around the Red Sea. **Solar and wind power** can be transmitted throughout the region via **H**igh **V**oltage **D**irect **C**urrent (**HVDC**) transmission lines, and to Europe with transmission losses up to 15%. The new Union for the Mediterranean, including many countries in MENA, is interested in this kind of cooperation.



For illustration: Areas of the size as indicated by the red squares would be sufficient for Solar Thermal Power Plants to generate as much electricity as is currently consumed by the World, by Europe (EU-25) and by Germany/MENA respectively. (Data provided by the German Aerospace Center (**DLR**), 2005)

4. The Technologies

Concentrating **S**olar Thermal **P**ower (**CSP**) plants are **ideal for providing secure solar** power. These types of power plants use mirrors to concentrate sunlight to create heat which is used to produce steam to drive steam turbines and electricity generators. Heat storage tanks (e.g. molten salt tanks) can be used to store heat during the day **to power steam turbines during the night** or when there is a peak in demand. In order to ensure uninterrupted service during overcast periods or bad weather (without the need for expensive backup plants), the turbines can also be powered by oil, natural gas or biofuels. As an interesting side effect (and of great benefit to local people), waste heat from the power-generation process may be used to **desalinate seawater** or to generate **cooling**.



Sketch of a **parabolic trough collector**
(A simplified alternative to a parabolic trough concentrator is the linear **Fresnel** mirror reflector.)

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The main reason for **favouring CSP over photovoltaics** is its ability to supply power on demand for 24 hours a day. PV is **more expensive** than CSP and needs **expensive** systems for **storing electricity**, such as pumped storage. If pumped storage facilities in Europe were to be fed with relatively large amounts of electricity from fluctuating sources from MENA, there would be a need for **more power lines** and those lines would be **under-utilized** since they would operate at full capacity for only a few hours each day.

HVDC transmission is very much more efficient than the use of hydrogen as an energy vector: Using **H**igh **V**oltage **D**irect **C**urrent (**HVDC**) transmission lines, loss of power during transmission can be limited to only about 3% per 1000 km. Although there would be transmission losses up to 15% between MENA and Europe, they are more than offset by the fact that levels of solar radiation in MENA are about twice what they are in southern Europe. Furthermore there is much less seasonal variation in levels of sunshine in MENA than there is in Europe.

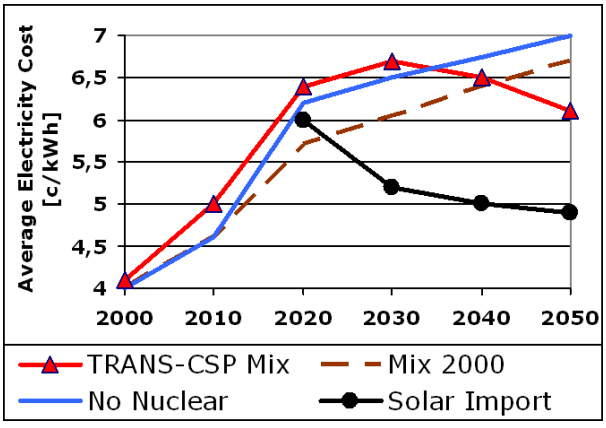
The technologies needed to realize the DESERTEC Concept have already been developed and some of them have been **in use for decades**. HVDC transmission lines up to 3 GW capacity have been deployed over long distances by ABB and Siemens for many years. In July 2007 Siemens won a bid to build a 5 GW HVDC System in China. At the World Energy Dialogue 2006 in Hanover speakers from both companies confirmed that the implementation of a Euro-Supergrid and an **EU-MENA-Connection** is, technically, **entirely feasible**.

Solar thermal power plants have been in use commercially at Kramer Junction in California since 1985. New solar thermal power plants with a total capacity **of more than 2000 MW** are at the planning stage, under construction, or already in operation. The Spanish government guarantees a feed-in tariff of **about 26 Eurocent/kWh for 25 years,** thereby establishing favorable business conditions for CSP in their country. Where there is more sunshine, it is possible to realize cheaper feed-in tariffs, as for example at good locations in Africa, America, China, India, Australia or MENA. The DLR has calculated that, if solar thermal power plants were to be constructed in large numbers in the coming decades, the estimated cost would **come down to about 4-5 Eurocent/kWh.** Because the costs for raw materials for solar thermal power stations are rising more slowly than the price of fossil fuels, CSP may become competitive earlier than previously expected. At the moment, production bottlenecks and strong demand are keeping prices high**.**

Parabolic trough collector field for the solar thermal power plant at Kramer Junction, California

Year		2020	2030	2040	2050
Transfer Capacity GW		2 x 5	8 x 5	14 x 5	20 x 5
Electricity Transfer TWh/y		60	230	470	700
Capacity Factor		0.60	0.67	0.75	0.80
Turnover Billion €/y		3.8	12.5	24	35
Land Area km x km	CSP	15 x 15	30 x 30	40 x 40	50 x 50
	HVDC	3100 x 0.1	3600 x 0.4	3600 x 0.7	3600 x 1.0
Investment Billion €	CSP	42	143	245	350
	HVDC	5	20	31	45
Elec. Cost €/kWh	CSP	0.050	0.045	0.040	0.040
	HVDC	0.014	0.010	0.010	0.010

Capacity, Costs & Space:
Development of the EU-MENA-Connection (marked 'HVDC') and Concentrating Solar Thermal Power (CSP) in the TRANS-CSP scenario between 2020 and 2050.



An example (Germany) of the **estimated cost of electricity in the future**, comparing the energy mix in the year 2000 with the TRANS-CSP Mix and showing the role of imported solar power.

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5. Measures to implement the DESERTEC Concept

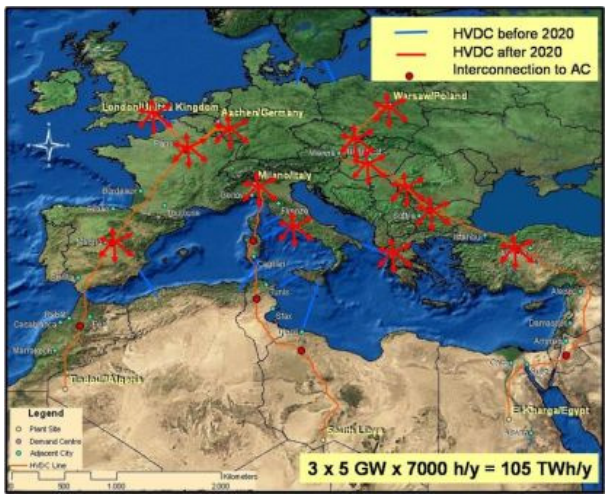
Construction of new concentrating solar thermal power plants **has already begun** in Spain and the USA (Andasol 1 & 2, Solar Tres, PS10, Nevada Solar One). Projects are underway in Algeria, Egypt and Morocco and further plants are planned in Jordan and Libya. **Morocco is implementing a feed-in law** to support wind power in particular. In the EU, discussions are in progress concerning the construction of an HVDC-Supergrid across Europe (a **Euro-Supergrid**) and plans for offshore wind farms in Northern Europe, with an associated HVDC Supergrid, are taking shape. The Union for the Mediterranean plans to realize a Mediterranean Solar Plan and could provide the framework for implementing DESERTEC in EU-MENA.

State support will be required **in the initial stages** to make the building of power stations and transmission lines attractive to private investors so that enough solar capacity may be created in the period up to 2050 to cover **the growing demands for power in MENA** plus **100 GW of power for export to Europe** (the equivalent of about 100 nuclear power stations). According to the DLR, less than 10 billion Euros of state support would be sufficient to bring CSP to the point where it would be competitive with fossil fuel-based power generation. Given the rising costs of oil and gas, this may well happen sooner.

The investments in constructing the cables and power stations could be undertaken by state governments, but international banks and private investors are ready to finance this infrastructure once the necessary conditions have been provided (as was made clear during the "10,000 Solar GigaWatts" event organized by TREC during the Hanover Fair 2008 — see www.Energy1.tv). Feed-in tariffs and investment guarantees are needed to get things moving. Southern European countries could offer feed-in regulations for clean power produced in MENA. It would also be possible that feed-in tariff regulations in MENA could be financed via "**Renewable Energy Credits**", which European countries would purchase, to reach a part of their climate protection goals, or (even better) to exceed these goals. Care should be taken to ensure that **renewable energy in Europe itself** should be expanded so that it is the major part of European energy supplies, as shown in the TRANS-CSP scenario up to 2050.

Whether the main focus of expansion of renewable energy in MENA is for domestic use or for export depends on the individual country: As an example, Morocco's energy need is so large that initially a credit system would be offered. By contrast, Tunisia and Algeria in particular show a strong interest in the export of solar electricity.

As soon as the Southern European countries start to import energy from MENA, this will have an effect on countries like Germany which currently exports electricity to Southern Europe. This would make more power available for Germany, reducing the incentive to build new fossil-based power stations and allowing more **time to expand into renewable energy sources**. Countries throughout Europe can begin to import a certain amount of clean energy from the south over existing cables, but the construction of **low-loss HVDC connections is urgently required**. Because the planning, approval and construction of cross-country connections takes many years, the necessary studies must start as a soon as possible.



EU-MENA-Connection: existing and planned HVDC transmission lines before 2020 (blue) and three traces researched by DLR (orange)

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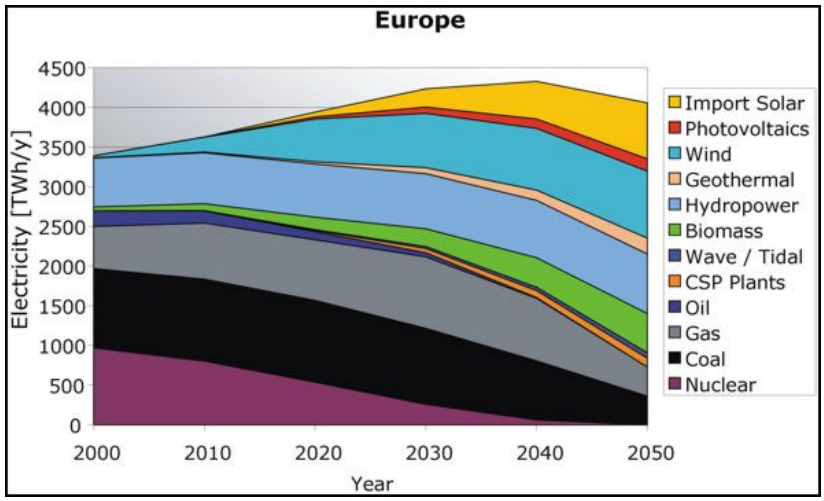
In addition to these direct supporting measures, TREC proposes **two projects** to help **bring down the cost** of CSP and at the same time to **alleviate pressing social and political problems**. Feasibility studies have shown that these projects are technically possible, but require political and financial support:

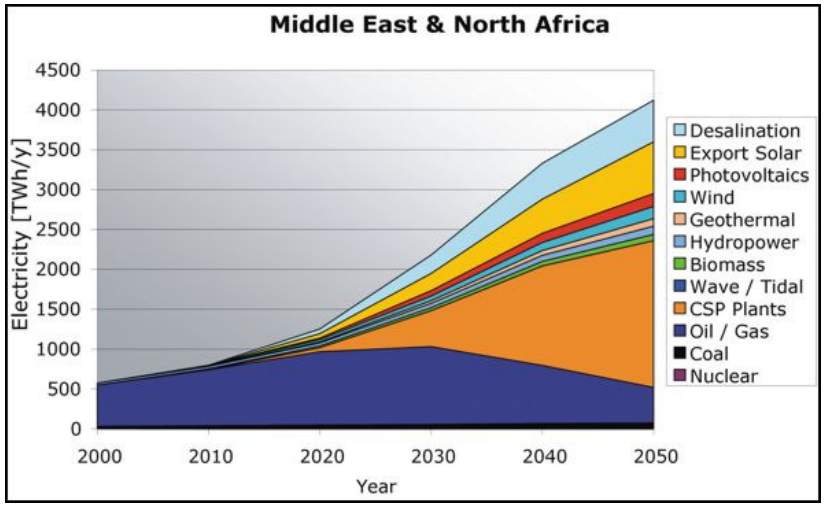
1. **Gaza Solar Power & Water Project:** To **build CSP plants** (1 GW in total) for the desalination of seawater and electricity generation. These plants, as part of a potential international recovery programme for Gaza, could be located in Egypt and provide power and water to 2-3 Million people in the Gaza strip. This project could make a huge difference to the living conditions and relieve the political tension in the Gaza region because it would reduce potential sources of conflict over shortages of water and because it would form the basis for healthy economic development. The total investment required would be about **5 billion Euros**.

2. **Sana'a Solar Water Project:** This project aims to build a **desalination plant** based on solar thermal energy near the Red Sea and to build a pipeline to the Yemenite Capital Sana'a which would otherwise be facing the exhaustion of its potable water reserves in about 15 years. This project could **avoid a looming humanitarian disaster and social unrest in Yemen**, and would save a cultural heritage of world-wide significance. The alternative of moving 2 million people from Sana'a to new settlements would cost about 30 billion Euros. By contrast, the alternative plan to build solar power plants and a pipeline would cost only about **5 billion Euros**, and would clearly be much better value.

The DLR's TRANS-CSP scenario shows **one viable approach**. Moreover, the countries of the EU-MENA region together have **more than enough potential to make a complete change** in favor of renewable energy for the power supply and transport sectors.

By the middle of the 21st century, the **MENA countries** could have converted their deserts to become inexhaustible sources of clean energy; overcome **limits of growth caused through shortages of fossil fuels.** At the same time they could sell clean power to European countries, thus helping to bring European down emissions of greenhouse gases **quickly**, with a **phase-out of nuclear power** and with **long-term reductions in the cost of electricity**.





TRANS-CSP **climate and supply security mix** in EU-MENA

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6. Answers to frequently asked questions

"Is this simply another way in which Europe will exploit Africa? What are the benefits for the MENA communities?!?"

- The **current situation is based on exploiting** limited resources like gas and oil, but **solar energy** is practically unlimited and as such, the owners **can't be "exploited"**.
- **In the period up to 2050,** the MENA Region **could** become as prosperous as **Europe** and urgently **needs renewables** for the generation of **electricity and drinking water** (considered in the TRANS-CSP study).
- **Saving fossil fuels** in the subsidized energy supply of African countries will allow selling the fuels more profitably on the world market.
- **Earnings from export** of electricity by using the unused potential of renewable energies.
- **Jobs** especially in the construction of solar collectors **==> income ==> building a middle class**, **instead of** the **emigration of well-qualified engineers**.
- **Consequences of climate change** produced by Europe will hurt the MENA region first, so it's only **fair if Europe supports** the introduction of renewables in MENA
- **Technology transfer** and development of **training programs and studies** for renewables in MENA is explicitly promoted by the European side in the framework of the Union for the Mediterranean

"Europe will be dependent on power supplies from abroad and these will be vulnerable to attack!"

- The electricity mix of the TRANS-CSP scenario in Europe in 2050: 65% European renewable energies, **17% solar electricity imports, 18% fossil fueled backup and peak load power plants ==>** Even the **loss** of all 20 HVDC lines from MENA **can be compensated for** until they have been repaired or until a political solution has been found
- There **won't ever be one huge solar power plant that could be knocked out in one go**. Instead, there will be hundreds of solar power plants in a network of renewables, spread over several continents.
- Using inexpensive and inexhaustible supplies of solar energy, there is also the possibility of **charging batteries** or generating **hydrogen** as a possible substitute for fossil fuels for transport. Furthermore there would be the possibility of releasing **biofuels** for use in transport instead of using them to generating electricity.
- **Solar energy** is virtually unlimited and is **getting cheaper as volumes increase** (instead of getting more expensive as with other energy sources) **==> no competition and conflicts** over regionally and quantitative limited resources, as happens with oil, gas and uranium.
- **Oil, gas or uranium** can be sold **more expensive after a suspension of deliveries ==> interruption of electricity exports** with renewables only leads to **loss of revenue** but no increase in costs.
- Interruption of electricity exports from a supplying country leads to **loss of confidence** in that country **==> less investment ==> fewer export earnings and less jobs** in future.
- See EU: **interdependence** rather than autonomy **ensures peace and cohesion**
- **Both public and private, small and large investors** can / should / want to invest into power plants and transmission lines
- **Time is short**: Climate change and price rises threaten us **==> decentralized and internationally connected renewables complement each other**

"Your approach includes only North Africa. What about the rest of Africa?!?"

- For a cooperation and integration into the European grid, MENA is – **because of its proximity to Europe** – obviously more suitable, than Central or South Africa
- Renewables in general and CSP in particular, **are also suitable for the rest of Africa** and it will profit by the cost reductions developed in the north.
- **Central Africa has large hydropower resources** considered by the North African countries (eg. Egypt) as a strategic reserve for its electricity supply. If North Africa, however, uses its own solar resources, Central Africa remains its most important resource.
- We also campaign there and in **China, Australia, America and India** for a realisation of DESERTEC "Clean Power from Deserts," but our resources are limited.
- That is why we are founding **regional DESERTEC Networks**, which can benefit from our know-how and the studies.