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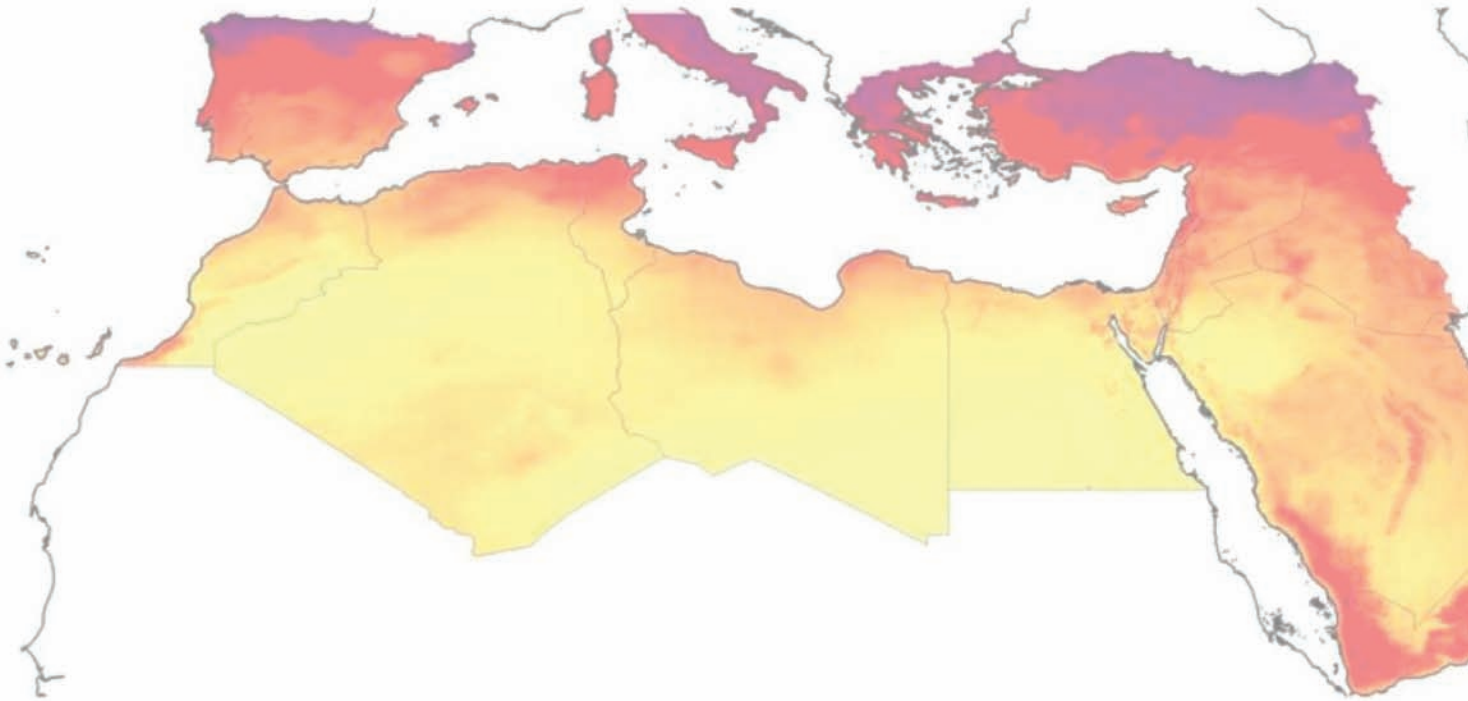
Student Research

DON'T STOP THINKING ABOUT TOMORROW:

Barriers to Trans-Mediterranean Trade in Solar Energy and What the European Commission Can do to Lower Them

Antoine Artiganave & Lukas Streiff



Belfer Center
for Science and International Affairs

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Barriers to Trans-Mediterranean Trade in Solar Energy and What the European Commission Can do to Lower Them

Dubai Initiative – Student Research

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EXECUTIVE SUMMARY

Climate change and energy security are two central challenges of the European Union. With these in mind, a variety of institutions from the public and private sectors have put forth different formulations of a promising policy proposal: trans-Mediterranean trade in solar energy.

Solar technology could be deployed at great scale in the superior conditions of North Africa to generate green electricity both for domestic markets and for transmission to European demand centers. The proposal has the potential to further diversify Europe's electricity mix and would ensure that a substantial part of North Africa's future generating capacity is carbon-neutral.

Trans-Mediterranean trade in solar energy is often depicted as a far-off, convoluted, and controversial mega-project that is to be either embraced or rejected. This study contests such a framing. Instead, North Africa's solar potential will be **realized diffusely and incrementally once relevant barriers have been sufficiently lowered**. Trans-Mediterranean trade in solar energy is inherently a long-term proposition. It will only become an actionable policy option for the EU if these barriers are addressed with **strategic attention and specific action today**.

Therefore, the two most pertinent questions at present are: What barriers must be lowered to turn the proposal into an actionable policy option? What actions are needed to lower each barrier? This study contributes an **analytical framework that disaggregates the barriers** into three categories.

The first set of barriers, namely the high cost of renewables, ineffective electricity transmission within the EU, and insufficient market integration and policy harmonization at the EU-level, is, in fact, **independent** from the proposal of trans-Mediterranean trade in solar energy. The EU is already working on lowering them and will continue to do so even if this proposal is not pursued.

The second set of barriers, namely, insufficient clarity regarding technology, high cost of renewables specifically in North Africa, lack of substantial trans-Mediterranean transmission, and inadequate legal and commercial frameworks in North Africa, is truly **dependent** and uniquely related to the proposal of trans-Mediterranean trade in solar energy. If Europe decided not to pursue this proposal, actions to lower the dependent barriers would not be required. Moreover, the proposal will not become an actionable option until and unless these barriers are lowered sufficiently. In essence the sum of actions, required to sufficiently lower the dependent barriers, represents the sunk cost that Europe must be willing to face if it wants to gain the option of realizing the proposal.

The third set of barriers, namely, allegations of neo-colonialism, the lack of regional integration, insufficient investment security, and energy dependence on North Africa is generally **overestimated** in its ability to prevent the realization of the proposal. These barriers can of course be lowered further but do not stand in the way of trans-Mediterranean trade in solar energy.

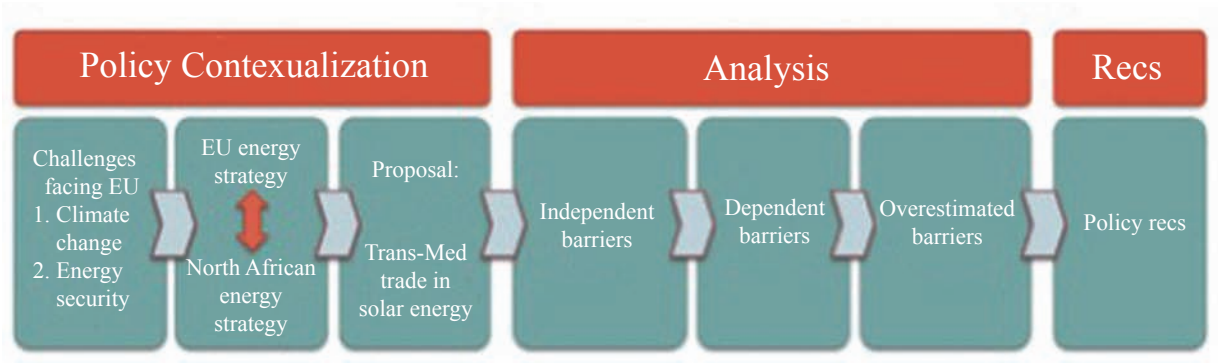
This study concludes that the European Union and its Member States should continue to lower the *independent* barriers with full force, engage the *dependent* barriers sufficiently to turn the proposal into an actionable policy option, and refrain from getting distracted by *overestimated* barriers. A key finding of this study is that three of the four dependent barriers can only be lowered if a variety of pilot plants are deployed on site in North Africa. We recommend reaching proof of concept through a **pilot phase** financed by international donor mechanisms as well as profits from virtual carbon trading, while the electricity generated should remain in North Africa at this stage.

OBJECTIVES OF THE POLICY ANALYSIS

1. Analytical approach

This study is a contribution to the ongoing policy debate on trans-Mediterranean cooperation in solar energy. It assumes the institutional standpoint of the European Commission (EC), specifically that of the co-clients: the offices of the European Commissioners for Climate Action and Energy. We aim to provide the Commissioners and officers of the EC with an analytical framework and recommendations as they evaluate policy options and ultimately craft a European strategy on the issue of trans-Mediterranean cooperation on solar energy.

The diagram below illustrates the analytical approach taken in this study. Starting from the central challenges of the co-clients – climate change and energy security – a brief overview of the current status quo of European policy is given, before the policy proposal in question here, i.e. trans-Mediterranean trade in solar energy, is introduced. We move on to summarize our findings about the perspectives of North African states on the proposal, before suggesting that both Europe and North Africa will decide to realize the proposal only if it helps them address their respective central challenges. Based on this, an analytical framework is put forward to help the European Union (EU) think about the proposal. This concludes the study's policy contextualization.



The core of this analysis is to identify and disaggregate the barriers that stand in the way of realizing the proposal. Three categories of barriers are identified that require specific actions:

- The first set of barriers is in fact *independent* from the proposal of trans-Mediterranean trade in solar energy; the EU and its Member States (MS) are already working on lowering them and will continue to do so even if the proposal is not pursued;

- The second set of barriers is truly *dependent* on the proposal of trans-Mediterranean trade in solar energy: actions to lower them would not be required if Europe decides against pursuing this policy option. However, Europe will not even reach the position to choose unless it lowers these barriers sufficiently for the proposal to become viable;

- The third set of barriers is generally *overestimated* in its capacity to prevent the realization of the proposal. These barriers can of course be lowered further but do not stand in the way of trans-Mediterranean cooperation in solar energy.

Based on this analysis, we recommend that the EU and its Member States continue to lower the *independent* barriers with full force, engage the *dependent* barriers sufficiently to turn the proposal into a viable policy option, and refrain from getting distracted by *overestimated* barriers. On each of the three categories, we give specific policy recommendations, culminating with a proposed pilot phase in North Africa that is essential to lowering three of the four dependent barriers.

This analysis, eventually, sheds light on the importance of unpacking long-term, ambitious, and complex policy concepts that engage various transversal – and oftentimes controversial – issues. Only then can institutions like the EC most effectively engage such concepts in the short- to medium-term, and lay the necessary groundwork today to ensure full "ability-to-act" tomorrow.

2. Policy question

This study contends that the solar energy potential of North Africa is undeniable but that immediate and large-scale realization of this potential remains out of reach under current fundamentals. The two central policy questions of this study therefore are:

- *What barriers would have to be lowered before trans-Mediterranean trade in solar energy even becomes a viable policy option?*

- *If the European Union wants this option to become available, what actions have to be undertaken to sufficiently lower each barrier?*

3. Scope

Solar vs. all renewables – Ultimately, the proposal in question here is very inclusive: it concerns trans-Mediterranean trade between Europe, the Middle East and North

Africa (MENA) in all forms of renewable energy. The study focuses only on the region's main potential for renewable energy i.e. solar power. This is not to suggest, however, that other forms of renewable energy should not be included in the future plans for trans-Mediterranean trade. Solar energy is, indeed, the big moving piece and will influence any future renewables trading system in the region, however, any such system is, nevertheless, certain to eventually include all forms of renewable energy.

Geographical scope – The geographical scope of this study has been deliberately kept limited in order to boost the study's internal validity: to gain sufficient depth of understanding of the wide-ranging subject of trans-Mediterranean cooperation in solar energy. We therefore conducted field research in only two countries of the MENA region: Morocco and Tunisia, which naturally limits the external validity of the study. While trans-Mediterranean trade would ultimately concern the entire MENA region, Morocco, Tunisia and Algeria constitute the most realistic starting point to trans-Mediterranean cooperation on solar energy. This is why the field research was conducted in Morocco and Tunisia while Algeria was included in the country analysis for this study.

The following criteria, among others, motivated the choice of Morocco, Tunisia, and Algeria: excellent solar irradiation, geographical proximity to Europe, strong existing political, economic, and cultural ties, precedents or expressed interest in cooperation with the EU, and active participation in current dialogue over renewable energy in the Mediterranean region. Morocco, Tunisia, and Algeria arguably represent the most promising partners for the first phase of any solar energy rollout strategy in the MENA region.

Solar technologies –This study might seem to favor 'concentrating solar thermal power' (CSP) over other solar technologies in its analysis and recommendations, but this is by no means the case. This study does not conduct an authoritative assessment of competing renewable energy technologies and, therefore, does not constitute a prospective exercise regarding their future costs. In the interest of scope, however, the study focuses on CSP technology in many parts of the analysis because it currently appears to be the most applicable technology for the purpose of economical, utility-scale electricity generation in North Africa. Were this assumption to be proven incorrect, the validity of the analysis would not be compromised. Indeed, this study puts forth an analytical framework that will guide European thinking about trans-Mediterranean trade in electricity based on any renewable energy technology.

This assumption is reflected in the recommendation regarding a pilot phase; all contending technologies should be represented amongst the pilot plants, but their relative distribution should mirror expert opinion about how promising each technology is. In designing the pilot phase, the EU should refrain from picking winners in the race between

technologies. However, it should not let this principle preclude resolute and immediate action, without which the dependent barriers will not be lowered sufficiently.

4. Methodology

The findings of this study are based on a review of academic literature, policy papers, media coverage, and other sources of pertinent information. They also draw extensively on field research and interviews with high-level decision makers conducted in January 2010 in Morocco, Tunisia, Belgium, Germany, and France. *Appendix 1* lists the respective names and affiliations of all 47 individuals interviewed over the course of this project.

Ultimately, the views expressed in this study remain those of the authors only and do not reflect the official policy or position of the European Commission, the Harvard Kennedy School, the Dubai Initiative of the Belfer Center for Science and International Affairs, or any interviewee or organization.

I. POLICY CONTEXTUALIZATION

1. Two central challenges facing the EU

Two wide-ranging challenges respectively top the priorities list of Commissioner Hedegaard and Commissioner Oettinger: climate change and energy security.

a. Climate change

Population growth, increased life expectancy, the need to maintain – if not improve – standards of living in developed countries, and the rapid industrialization of emerging economies striving for prosperity are dramatically expanding the global demand for energy and water.[1] Our current socio-industrial model, based predominantly on fossil fuels, is putting an ever-greater stress on the environment, leading to higher global temperatures and causing climate change.

In the medium- to long-term, this situation could lead to new conflicts over resources, while climate change could generate flooding, intensify desertification, engender disasters, and trigger unprecedented mass migrations.

The EU is addressing this challenge by embracing the following objectives:

- Assume political leadership in the fight against global climate change;
- Agree on strict cuts in greenhouse gas (GHG) emissions in Member States;
- Promote clean electricity generation and conversion of generating capacity.

b. Energy security

The European Union is simultaneously confronted with growing energy consumption needs and strong dependency on imported oil and gas. In the context of global competition for, and continuous depletion of, natural resources, potential supply failures and price instabilities constitute serious challenges to European energy security. In 2007, EU Member States collectively imported 53.1% of all fuels (a figure that could reach 70% by 2030[2]), 82.6% of oil and 60.3% of gas.[3] Their main crude oil exporters were Russia (34%), Norway (15.5%), Libya (10.2%) and Saudi Arabia (7.2%), while their main gas exporters were Russia (40.8%), Norway (26.7%), Algeria (16.9%) and Nigeria (5.1%).[4]

The EU is addressing this challenge by embracing the following objectives:

- Diversify the mix of imported energy resources, the number of supplier countries, and the transport routes;
- Integrate energy markets and regulatory bodies to incentivize reliable, efficient, and competitive distribution of energy within Europe;
- Increase the interconnection of the transmission grids of oil, gas, and electricity within Europe to decrease individual country dependence;
- Increase electricity grid connections across the continent to allow for the maximal use of renewable energy utilization and to manage intermittency;
- Promote energy efficiency.

In summary, the two central interests of the EU are to:

- Minimize CO_2 emissions from electricity generation;
- Maximize energy security.

2. Current strategy, status quo, and policy update

a. Current EU policies

The European Union has initiated a variety of ambitious policies aimed to address the challenges of climate change and energy security. Below is an overview of the EU's strategy, featuring some of the most relevant policy tools currently at its disposal. This, by no means, constitutes an exhaustive list of European legislation or initiatives pertaining to the two challenges in question.

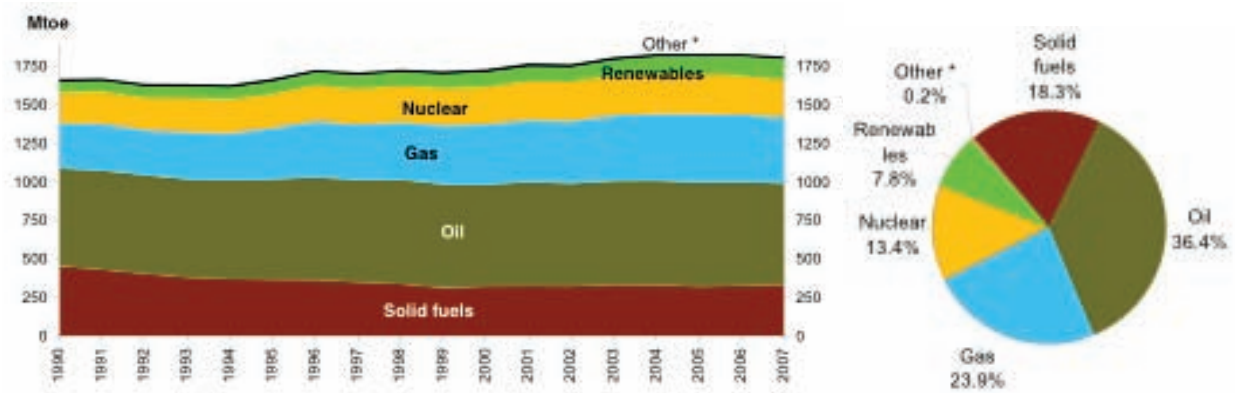
	Climate Change	Energy Security
Embraced objectives	▪ Political leadership globally ▪ Strict GHG emissions cuts targets ▪ Clean electricity generation and capacity conversion	▪ Energy efficiency and diversification strategy ▪ Integration of markets and regulators ▪ Transmission grid upgrade
Key policy tools/ initiatives	• "20-20-20" plan [a] • EU-wide Emissions Trading System [b] • New commissioner for Climate Action • Dedicated ETS revenues to promote CCS and renewables [c]	• Energy "chapter" in Lisbon Treaty [d] • Various efficiency directives and plans [e] • Creation of ENTSO-E [f] and ACER [g] • "Strategic Energy Technology" plan [h] • Major alternative gas routes projects [i]

(a)	The 2008 "Climate and Energy Package" introduced the target of 20% GHG emissions reduction below 1990 levels by 2020. Directive 2009/28/EC further binds MS to differentiated national contributions of renewables in the energy mix towards a 20% EU-wide target, and directs each MS to satisfy 10% of their transport fuel needs from renewables subject to specific sustainability criteria. This directive allows for statistical transfers between MS and for "joint projects with third countries".
(b)	Directive 2009/29/EC strengthens and expands the Emissions Trading System (EU ETS), instituting a EU-wide cap on ETS emissions, organizing the progressive replacement of free allocation of emission allowances by their auctioning (by 2020), and promoting the development and safe use of CCS.
(c)	On February 2, 2010, MS agreed to allocate revenues (€6 billion estimate) from the EU ETS to support CCS technology and renewable energy by setting aside 300 million allowances from the scheme's "new entrants reserve". While this agreement was criticized by some as largely favoring CSS relative to renewables in terms of funding, most observers acknowledged the political significance of EU-level money being directly allocated to such goals. Final adoption of the decision is due May 2010.
(d)	The recently ratified Lisbon Treaty features a specific energy chapter, mandating EU policy to ensure proper functioning of the energy market with a focus on energy supply, promotion of efficiency and saving, development of renewable sources, and interconnection of energy networks (cf. Art. 176 A).
(e)	Cf. Directive 2002/91/EC (energy performance of buildings), Directive 2006/32/EC (energy end-use efficiency and energy services), and 2009 "Evaluation and Revision of the Energy Efficiency Action Plan," committing MS to saving 20% of primary energy consumption by 2020.
(f)	Regulation (EC) No. 714/2009 established the European Network of Transmission System Operators for Electricity (ENTSO-E) in replacement of all 6 existing European TSO associations.
(g)	Regulation (EC) No. 713/2009 created the Agency for Cooperation of Energy Regulators (ACER) tasked with the coordination of national regulatory authorities, elaboration of European network rules, and issuance of binding decisions on cross-border energy infrastructure. On December 6th, 2009 EU member states decided that ACER would have its seat in Ljubljana, Slovenia. The new agency needs to be fully operational as of March 3rd, 2011 in accordance with its founding regulation.
(h)	The Strategic Energy Technology (SET) plan calls, among others, for investment in electricity grids to integrate renewables and begin the rollout of "smart grid" operational principles. With an estimated cost of €2 billion over the next ten years, this policy proposal initially targets 50% of networks in Europe.
(i)	Three main projects are currently pursued: "Nord Stream" connecting Russia-EU via Baltic sea, transport capacity of 55 billion m^3/year, scheduled for 2011/2012; "South Stream" connecting Russia-EU via Black sea, 63 billion m^3/year, scheduled for end of 2015; "Nabucco" connecting Caspian region-Middle East-Egypt-EU, 31 billion m^3/year, scheduled for end of 2015.

b. Status quo of renewable energy in the EU

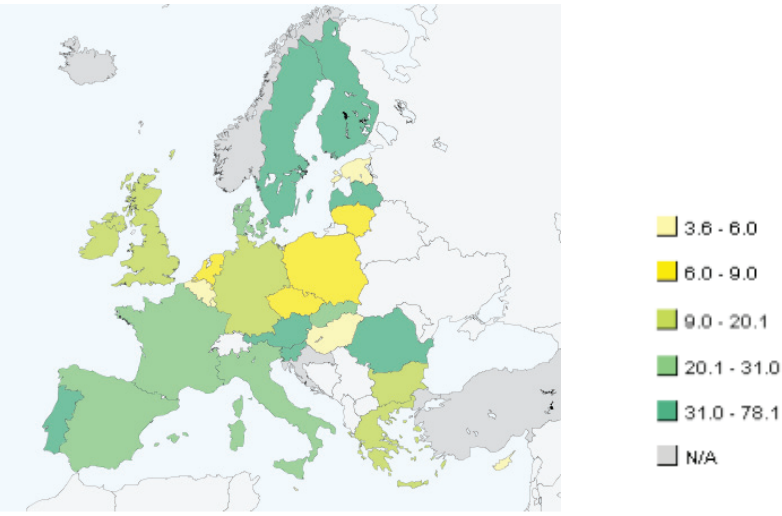
Renewable sources of energy represented 7.8% of the European Union's 2007 gross inland consumption mix, comprising the following breakdown: biomass (69.8%), hydro (18.9%), wind (6.4%), geothermal (4.1%) and solar (0.9%).[5]

***Figure 1*. EU-27 gross inland energy consumption (by fuel, in Mtoe) and 2007 breakdown**



Source: Eurostat and DG TREN Statistical Pocketbook 2010.

***Figure 2*. 2010 projected "clean" electricity generation as a percentage of consumption**



Source: Eurostat 2010.
Note: Represents the ratio between the electricity produced from renewable energy sources and the gross national electricity consumption. EU-27 projected clean electricity generation = 21%.

c. Update on the "Europe 2020" strategy

On March 3rd 2010, the EC communicated its "Europe 2020" plan.[6] It contained various announcements adding to, or building on, the current EU policy toolbox vis-à-vis the two central challenges outlined above:

- Reaffirmation of the EU's existing "20-20-20" climate goals (no mention of potential upward revision to 30%[7]);
- "Flagship initiatives" on resource efficiency, clean and efficient energy, and industrial policy hinting at a €60 billion decrease in oil and gas imports by 2020;
- Proposed establishment of a long-term roadmap for low-carbon energy systems by 2050 and adoption of a revised Energy Efficiency Action Plan;
- Planning of a WTO trade strategy geared towards removing all custom-duties on "green products" and greater cooperation on international standardization issues;
- Impending major plan to upgrade energy networks towards a European supergrid, "smart grids" and interconnections (especially Trans-European Energy Network);
- Promotion of infrastructure projects of "major strategic importance to the EU", including in the Mediterranean with support from structural funds and the EIB;
- Upcoming strategy to remove obstacles towards a single market for renewables.

II. A PROMISING POLICY PROPOSAL: TRANS-MEDITERRANEAN TRADE IN SOLAR ENERGY

1. Rationale

In light of current EU priorities and consequent policies, an emerging concept is gaining considerable traction: trans-Mediterranean trade in renewable energy with a focus on solar power. Its origins as a scientific project date back to a 2005 influential study by the German Aerospace Center (DLR) on which most of the ensuing policy discussion is based.[8] Articulated in various policy formulations since, this concept capitalizes on the singular geographical proximity between a growing market with terrific potential for renewables technology (North Africa) and a developed market that focuses on maximizing the use of green electricity (the EU).

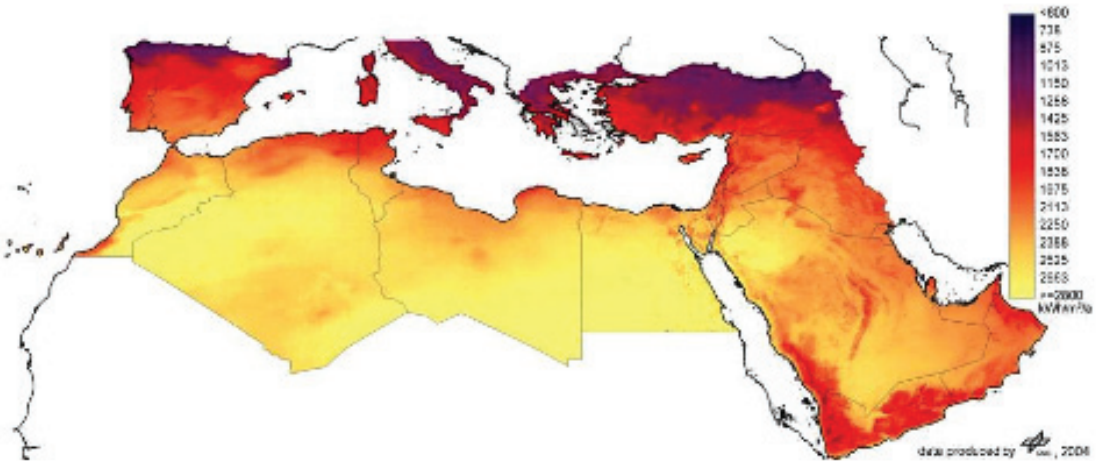
Trans-Mediterranean trade is pertinent for three main reasons:

- North African countries have a clear comparative advantage in solar power generation due to some of the world's strongest solar radiation at around 20-30% higher than at the best sites in Europe (cf. *Figure 3*);[9]

- The EU is at the policy forefront of, and has proven its relative willingness to pay for, "clean" energy. It is looking to diversify its supply and promote renewables;

- The cost and operational feasibility determinants of transmission, which historically hindered similar infrastructural projects, now seem to allow for it.[10]

***Figure 3*. Annual normal direct solar irradiance in the EU-MENA region**



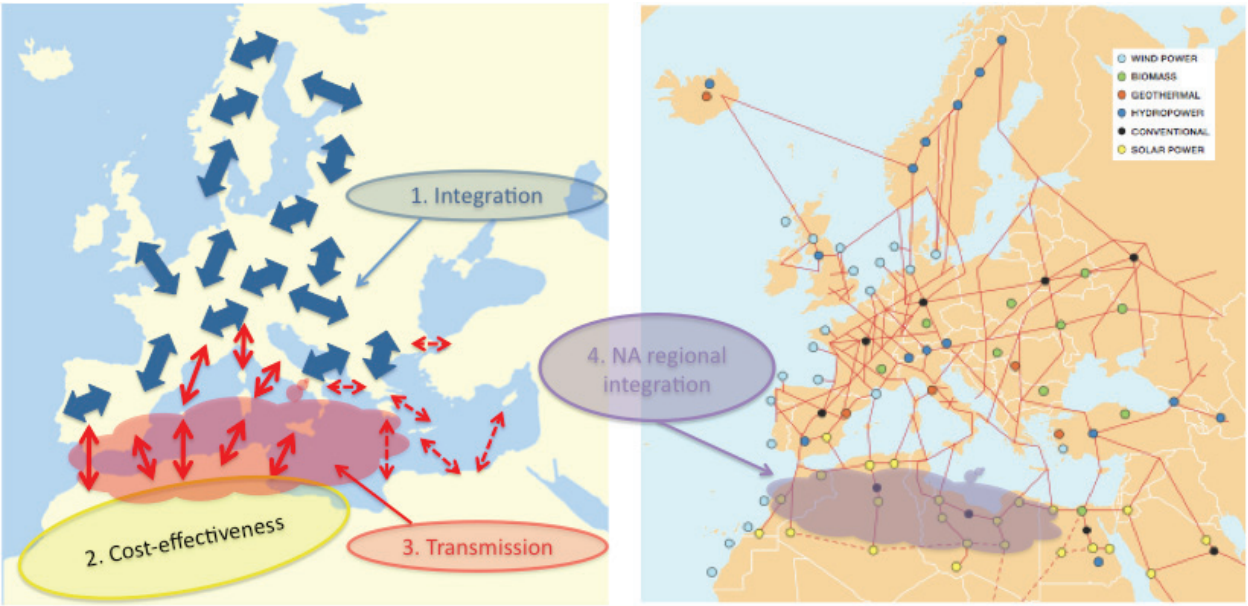
Source: Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), 2005.

North Africa could provide the EU with a new supply source of clean electricity to support its climate change and energy security strategy. With more than 90% of the world's population living within 2,700 km of a hot desert (see *Appendix 2* for a map of global solar irradiance),[11] a successful proof of concept could also signify the start of a global rollout bringing value and carbon-neutral power to overlooked areas of the world. Though trans-Mediterranean trade first and foremost addresses Europe's strategic priorities, its successful implementation could have wide-ranging development implications for the MENA region.

2. Key characteristics

Trans-Mediterranean solar trade will only materialize if both North Africa and Europe see joint value in it. This, however, first requires that the following three conditions be met:

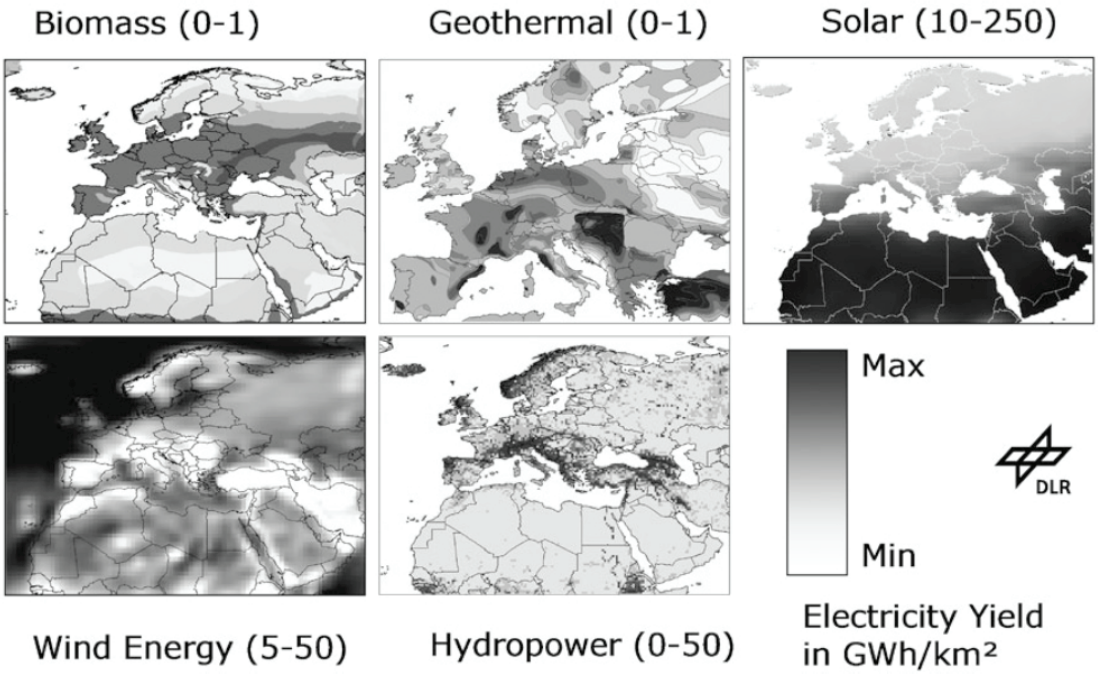
- Electricity markets in Europe are *integrated* enough to increase absorption capacity and allow for renewables trading;
- Renewables in North Africa have become *cost-effective* for consumers in both regions: they are rolled out in large-scale for domestic consumption and exports;
- Cross-Mediterranean *transmission* with minimal loss is laid.



Sources: Left side – authors; Right side – Adapted from SolarPACES, Greenpeace International, and ESTELA, "CSP Global Outlook 2009."

Cooperation on solar energy could begin on a bilateral basis between the EU and individual North African countries. Ultimately, the long-term optimal outcome of full-scale renewables trading through a complete Mediterranean loop would necessitate market integration and transmission building across North Africa. Following that, Europe and North Africa would capitalize on their respective comparative advantages (cf. *Figure 4*) and pursue the holistic vision of a fully integrated and interconnected EuroMed energy market; a renewables "orchestra" in which all sources contribute to the mix.

***Figure 4*. Comparative advantages in renewables around the Mediterranean**



Source: Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), 2005.

3. Current policy landscape

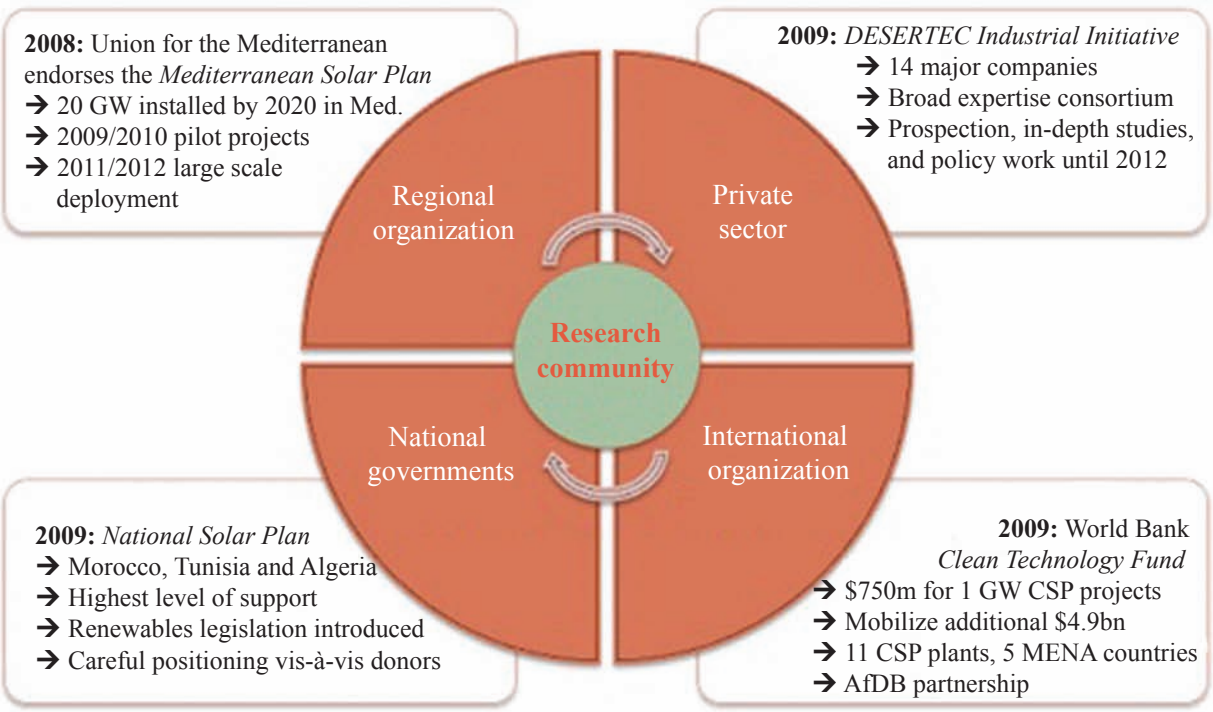
The concept of trans-Mediterranean solar trade originated in the scientific and engineering research community-at the forefront of which, stood the Trans-Mediterranean Renewable Energy Cooperation (TREC). Founded in 2003 as an initiative of the Club of Rome and the Hamburg Climate Protection Foundation, TREC greatly contributed to the dissemination of the solar cooperation concept. This network is now known as the DESERTEC Foundation.

A testament to the work of these researchers, the concept has gained considerable traction since, spurring both public and private interest.[12] Four independent and successive formulations have emerged in the policy landscape: respectively, the *Mediterranean Solar Plan* of the Union for the Mediterranean; project *DESERTEC,* now pursued by

the private sector industrial consortium DESERTEC Industrial Initiative; the World Bank's *Clean Technology Fund* announcement of a large set of loans for CSP projects in the MENA region; and *National Solar Plans of* individual North African states.

While these projects oftentimes have been independently analyzed – and sometimes opposed – in the European media, it is critical to appreciate and further investigate their potential complementarities. In fact, the current policy landscape features committed interest from:

- An EU-linked regional organization with political and potentially financing capacity (Union for the Mediterranean);
- An industrial consortium with broad technical expertise and substantial capital raising ability (DESERTEC Industrial Initiative);
- An international development bank with global clout and the ability to raise complementary funds, a strong desire to be more present in the region, and a solid track record in clean energy funding (World Bank);
- Local North African governments, eager to position themselves strategically by putting forth individual plans that enjoy highest-level domestic political backing.



Source: Authors.

Most critically, these initiatives share in common a holistic regional approach, recognition of the EU as a pivotal player, an understanding of the long-term nature of the project, and a stoutly supportive stance regarding private sector involvement.

Finally, in addition to addressing two central European challenges, trans-Mediterranean cooperation offers a new and promising policy insight into the post-Kyoto climate agreement architecture debate. While climate change is the quintessential embodiment of a *global* commons problem, *international* – if not *regional* – cooperation schemes are now increasingly being seen as more effective policy responses.[13] As pointed out by the proceedings and arguably suboptimal outcomes of the December 2009 United Nations Climate Change Conference in Copenhagen, the limits of large-scale, unanimity-based avenues for policymaking of such magnitude and scope are real. The trans-Mediterranean framework thus could prove a useful tool for the EU as it continues to seek incremental progress on climate agreements, in parallel with Kyoto's eventual successor.

4. Need for an independent strategy of the European Commission

As founding members of the Union for the Mediterranean (UfM), EU Member States were full parties to the endorsement of the Mediterranean Solar Plan (MSP).[14] Though the UfM experienced a difficult launch,[15] a general consensus exists in Europe around the relevance of the MSP. In fact, EU Member States are currently reviewing the MSP's latest communication in anticipation of a high level ministerial conference in Valencia (May 11-12, 2010) where talks shall resume.

Response to the World Bank's announcement (when noticed) has also been quite warm in the EU. This is mostly due to the close – if at times competitive – relationship that exists on the ground between the World Bank and European development institutions such as EU delegations, KfW, AfD or GTZ. However, reactions to DESERTEC and national solar plans were much more nuanced as European policymakers remained cautious of the former's intentions and skeptical as to the latter's ability to find financing.

As an institution, the EC is yet to openly and fully partake in the policy discussion by contributing its own strategic vision. With the exception of the MSP (due to obvious institutional linkage), EU positioning so far has only taken the form of ad hoc, informal statements of support.[16] It is time the EC moved beyond detached endorsement and started thinking strategically about the EU's role in realizing the concept of trans-Mediterranean trade in solar energy.

III. NORTH AFRICAN PERSPECTIVES ON THE PROPOSAL

Trans-Mediterranean trade in solar energy will be realized only if it proves a viable "win-win" proposition for both parties. North Africa has different priorities than the EU, however. To gain traction in this region, the proposal must help address the following two key interests of North Africa:

- Economic development by capitalizing on the comparative advantage in solar energy;
- Meeting burgeoning electricity demand.

1. The priority of economic development

Economic development is the first priority of all North African states. GDP per capita in Morocco, Algeria and Tunisia respectively reached $4,587, $6,855, and $8,285 in 2009.[17] A look at the individual trade balances of these countries (cf. *Figure 5*) uncovers several weaknesses:

- *Morocco*: heavy reliance on imports of energy and equipment; concentration of exports in consumption goods and other low value-added semi-finished products;
- *Tunisia*: similar import-reliance patterns as Morocco, but with a smaller trade deficit due to large exports (37%) of relatively higher value-added consumption goods:
- *Algeria*: total dependency on energy exports (98% of total) and therefore on commodities markets; import-reliant for most other goods (especially food).

***Figure 5*. Individual country merchandise trade balance ($ million, 2007)**

Morocco

Category	Exports: Millions of dollars	Exports: Percent	Imports: Millions of dollars	Imports: Percent	Balance (millions of dollars)
Consumption goods	4,106	30.1	5,525	18.9	−1,419
Energy	288	2.1	5,833	20.0	−5,545
Equipment goods	1,572	11.5	6,377	21.8	−4,805
Food products	2,463	18.1	3,005	10.3	−542
Primary products	1,425	10.4	1,776	6.1	−351
Semifinished products	3,783	27.7	6,719	23.0	−2,936
Total	13,638	100.0	29,235	1.0	−15,598

Tunisia

Category	Exports: Millions of dollars	Exports: Percent	Imports: Millions of dollars	Imports: Percent	Balance (millions of dollars)
Consumption goods	5,568	37.3	1,936	10.3	3,632
Energy	2,416	16.2	2,311	12.3	105
Equipment goods	2,103	14.1	5,001	26.6	−2,898
Food products	896	6.0	1,323	7.0	-427
Primary products	1,038	6.9	375	2.0	664
Semifinished products	2,924	19.6	7,871	41.8	−4,947
Total	14,945	100.0	18,818	100.0	−3,872

Algeria

Category	Exports: Millions of dollars	Exports: Percent	Imports: Millions of dollars	Imports: Percent	Balance (millions of dollars)
Consumption goods	33	0.1	4,009	14.6	−3,976
Energy	55,705	97.7	313	1.1	55,392
Equipment goods	46	0.1	10,097	36.8	−10,051
Food products	87	0.2	4,827	17.6	−4,740
Primary products	170	0.3	1,277	4.7	−1,107
Semifinished products	978	1.7	6,919	25.2	−5,941
Total	57,019	100	27,441	100	29,577

Source: Faïd (2008); Morocco: Centre Marocain de Promotion des Exportations, www.cmpe.org.ma; Algeria: Agence Nationale de Promotion des Exportations, www.promex.dz; Tunisia: Institut National de Statistique.

a. Opportunities for export-driven growth

As developing economies, these three countries face the challenge of moving up the value-chain in terms of the products they manufacture and export.[18] For Morocco and Tunisia, this could mean capitalizing on their solar endowment; for Algeria, this could mean diversifying its exports and increasing the amount of exportable gas by replacing domestic gas consumption for electricity generation with electricity generated from renewables.

Section III.1 introduced the notion that trans-Mediterranean solar trade could help meet burgeoning North African demand for electricity but cooperation could also contribute to local economic development. Three main reasons can be cited for that:

- Solar energy qualifies as a high value-added good for which a robust, fast-growing, and profitable export market could develop in Europe;
- A large-scale solar rollout would imply substantial infrastructural investments from which the entire economy could benefit;

- Increased economic activity and technology transfers concomitant to such a rollout would generate positive externalities throughout the economy (e.g. knowledge spillovers, greater capital availability, incentivizing entrepreneurship, R&D, etc.).

b. Opportunities for employment

Trans-Mediterranean solar trade holds a second development promise: high value-added industry employment, both in plants O&M and components manufacturing (e.g., mirrors, collecting tubes, heat absorbers, turbines, or HVDC cables).

Solar industry group ESTELA claims that by 2020 the MSP could create as much as 35,280 permanent O&M jobs,40,000 manufacturing jobs in North Africa (and as many in Europe), and 120,000 construction jobs. [19] It contends that every 100MW of installed CSP could provide 400 man/year-equivalent manufacturing jobs, 600 in contracting and installation, and 60 in O&M. ESTELA further invokes virtuous multiplier effects for the surrounding community of about four service jobs created in support of one construction job.[20] DESERTEC finally argues that one 250MW parabolic trough power plant would require 1,000 workers and engineers for up to three years.[21]

In light of such ambitious figures, one ought to keep in mind the relatively low-skilled character of the North African workforce. It is therefore unlikely that most of these high value-adding jobs would benefit local employment pools, at least in the short-term. Morocco, Algeria, and to a lesser extent Tunisia, still remain predominantly low-skill, low-cost labor markets. While local parts contributions and strategic supply-chain management opportunities cannot be excluded, Spain, Germany, the U.S., and increasingly China, will continue to house most of the components manufacturers in solar plants.

The World Bank is currently preparing a study on job creation in the context of solar technology deployment – a critical analysis that will hopefully shed greater light on the employment dimension of trans-Mediterranean cooperation in solar energy.

2. The challenge of burgeoning electricity demand

North African populations are young and growing at an average annual rate of 1.3%, compared to 0.1% in the EU.[22] By 2020, Morocco, Algeria, and Tunisia are estimated to have 13 million more inhabitants than today, at a total of 89 million. Corollary to this demographic growth, economic activity and electricity demand are expected to soar (respectively +4% and +7% annually).[23] *Appendices 3* (population), *4* (GNP) and *Figure 6* (energy) below provide a regional overview of key trends.

***Figure 6*. Demand for energy in North Africa**

	Primary energy (mtoe)			Oil (million tons)			Natural gas (mtoe)			Renewable energy (mtoe)			Coal (mtoe)			Electricity (TWh)		
Country	2006	2010p	2020p	2006	2010p	2020p	2006	2010p	2020p	2006	2010p	2020p	2006	2010p	2020p	2006	2010p	2020p
Algeria	34.0	40.0	61.8	11.7	13.0	15.0	21.5	26.0	45.5	0.1	0.1	0.4	0.7	0.8	0.9	34.4	46.1	85.5
Libya	18.7	23.5	28.5	13.2	12.3	13.3	5.3	11.0	15.0	0.2	0.2	0.2	0.0	0.0	0.0	24.0	35.0	48.3
Mauritania	1.2	1.4	1.7	1.0	1.2	1.2	0.0	0.0	0.0	0.3	0.3	0.4	n.a.	n.a.	n.a.	0.4	0.5	0.7
Morocco	12.6	16.6	20.0	7.6	8.4	9.5	0.6	2.3	5.2	0.5	0.6	0.7	3.4	4.0	4.2	19.2	27.4	37.3
Tunisia	8.9	12.6	16.1	4.0	6.8	7.6	3.7	4.5	7.0	1.0	1.2	1.4	0.1	0.1	0.1	13.5	16.3	28.4
Total	75.4	94.1	128.1	37.4	41.7	46.6	31.1	43.8	72.7	2.0	2.4	3.2	4.3	4.9	5.3	91.4	125.3	200.1

Source: Faïd (2008); International Energy Agency; BP Statistical Review of World Energy 2007; Observatoire Méditerranéen de l'Energie; CEDIGAZ; and authors' estimates.

As will be discussed in section III. 3, the energy sectors of Morocco, Algeria, and Tunisia differ greatly. All three countries must, however, add substantial amounts of electricity generating capacity in the coming decades and are therefore evaluating different technologies. Conservative figures estimate annual electricity demand in 2020 to be 40 Terawatt-hour (TWh) higher than today in Algeria, 18TWh higher in Morocco, and 15TWh higher in Tunisia –this represents an increase of over 100% in each country.[25]

Meeting this burgeoning electricity demand is a key challenge to North Africa. Only if trans-Mediterranean cooperation in solar energy would help North Africa address this challenge, will the proposal receive public support and the necessary backing from governments in North Africa. Governments will soon begin to add power generating capacity and their choice of technology is only marginally influenced by carbon emissions. Solar energy will figure prominently in the technology mix of future generating capacity only if it quickly becomes an economical and advantageous option. . The following chapter sheds more light about the approach of each country to these decisions.

3. Differentiated national strategies

Though Morocco, Algeria, and Tunisia share a common geography and similar demographic trends, they differ greatly in terms of their political agendas, resource endowments, and energy policies. *Appendix 5* summarizes the status of energy consumption, imports and exports in the region. The differences between these three countries are very representative of the entire MENA region, and they lead to substantially different policy positions regarding the proposal of trans-Mediterranean trade in solar energy. Table 1 provides a stakeholder analysis at the country level.

Table 1. Overview of country-level insights

	Morocco	Algeria	Tunisia
Structural constraints	• Net energy importer: 14 Mtoe (dependent) • Pop. growth: 1.2% • GDP growth: 3.2% • Electricity demand growth: 6.0%	• Net energy exporter: 127.5 Mtoe (rich) • Pop. growth: 1.5% • GDP growth: 3.7% • Electricity demand growth: 7.4%	• Net energy importer: 1 Mtoe (dependent) • Pop. growth: 1% • GDP growth: 4.0% • Electricity demand growth: 6.5%
Policy relationship with EU	• Closest in the region (advanced status) • Sees EU as a "label" (reg/leg convergence) • Cooperation "posterchild" for the EU	• Cooperation in existing energy pipelines: Trans-Med, Maghreb-Europe and Medgaz • 17% of EU's gas imports; 90% of Algerian crude oil to Western Europe • Occasional trade disputes, immigration issues	• Close (especially with France and Italy) • Solid working relationship with EIB (annual lending reported to double to $900 million in 2010)
Local challenges for the EU	• "Image deficit" (visas, tomatoes, etc.) • Competition from Gulf (financing), China (infrastructure), U.S. (diplomacy) • Western Sahara stalemate	• Adversarial stance towards EU at times • Ties with the U.S. (1st exports partner, nuclear cooperation, technical assistance) and increasing influence of China	• Authoritarian nature of regime • Political succession issues complicates long-term planning
Political backing for trans-Med. concept	• Highest level (H.M. Mohammed VI) • Explicit mention of MSP and DESERTEC in royal messages and ministerial speeches	• Initially low (oil/gas focus) but evolving rapidly under presidential leadership • Positive spinning of DESERTEC through influence within OME	• Highest level (President Ben Ali)
Enabling factors	• Geographical proximity and existing transmission to Spain • History of political stability • Safe investment climate and steady business environment reforms • Extremely proactive towards trans-Mediterranean partnership • Domestic company is a member of DII • Influential and respected GTZ presence in ministry of energy • Strong AfD presence (largest lending post globally, €400 million in 2009)	• Conscious of export dependency • Potential for CSP in hybrid plants with gas • Domestic company is a member of DII • Track record of transmission infrastructure involving foreign companies • Siemens heavy presence in local infrastructure projects • Cooperates on Trans-Saharan pipeline	• Geographical proximity to Italy • State bureaucracy relatively prepared • Friendly investment framework for large corporations ("off-shore" regime) • Proactive in seeking Med. Partnership • Talks of STEG joining DESERTEC • World Bank is "back" in Tunisia (El-Med)
Potential threats	• Relative unpreparedness of local actors, despite substantial efforts underway • Uncertain domestic financing sources • Job-creation claim remains questionable (mostly unskilled labor) • Possibility of inter-agency competition • Precedent of "Chourouk Initiative" • Relations with Algeria severely limit regional integration • Risk of conflation with Western Sahara dispute • Sub-Saharan Africa being "left out"?	• Economic nationalism and *dirigisme* • Liberalization of electricity market stalled • Barriers to FDI • Third nuclear reactor on the way? • Relations with Morocco severely limit regional integration • Terrorism: *al-Qaeda in the Islamic Maghreb* based in Algeria	• Limited scalability due to small area • El-Med project still in stalemate (though EC financing for Sicily-continental Italy) • No domestic company is a member of DII • Job creation claim remains questionable (mostly unskilled labor) • Uncertain domestic financing sources • Solar or "energy efficiency" focus? • Lack of overall regional integration limits trade opportunity westward

Source: Authors.

a. Morocco and Tunisia: (getting) ready for action

In a quickly evolving policy landscape in late 2009, Morocco and Tunisia presented their national solar strategies with alacrity and high publicity.[25] Some of the political fanfare certainly had to do with long-standing regional competition, but it also underlined the fact that the promotion of solar energy enjoys backing from the highest political order in both countries: H.M. Mohammed VI of Morocco and President Ben Ali of Tunisia made solar energy a personal priority and have publically supported trans-Mediterranean cooperation.[26] The political, economic, and bureaucratic elites of both countries are convinced that solar energy represents a comparative advantage and potentially a great source of future income.

Morocco and Tunisia are both net energy importers[27] who are very interested in diversifying their energy mix by developing domestic sources; however, they are currently unable to cover the cost premium of renewable energy. The concept behind the renewables strategies of Morocco and Tunisia is based on foreign investment and support from the donor community and institutions like the World Bank and the European Union. The governments intend to do everything necessary to attract partner funding to finance the deployment of renewable energy, but they do not intend to commit more than petty sums themselves.

In their bid to attract outside funding, Morocco and Tunisia are pursuing EU-oriented legislative and regulatory reforms. Renewable energy laws and regulations have been introduced and new agencies were created to coordinate the deployment of renewables energy technology in both countries. Governments also coordinate the initial prospection of sites and subsequent feasibility checks before a project list is pitched to investors. So far, however, progress remains slow. In short, Morocco and Tunisia are lining up and getting their “houses” in order, but still face – and acknowledge – substantial financing needs.[28]

For all the enthusiasm found in Moroccan and Tunisian policy circles, local support for trans-Mediterranean solar cooperation will not come unconditionally. For both political and economic reasons, policymakers are carefully framing the issue in terms of job creation, industrial cluster development, R&D cooperation, and technology transfer. As was discussed above, trans-Mediterranean cooperation on solar energy will inevitably bring employment to the region – primarily in the form of construction work – but as the sourcing of skilled labor remains problematic, Moroccan and Tunisian hopes for job creation could be disappointed. The EU must be mindful of this risk as it could undermine political and public support for the proposal.

b. Algeria: The need to prepare for the future

Algeria is of critical importance to the proposal of trans-Mediterranean trade in solar energy because it is the country with the largest solar potential. It boasts the best solar irradiation in the region (more than 2,000 kWh/m^2/year of direct sunlight[29]), and far larger desert area than small Tunisia and coastal Morocco. Once solar energy is rolled out on a substantial scale in the region, Algeria becomes indispensible.

Since Algeria has substantial natural gas and oil reserves,[30] it views solar energy very differently than Morocco or Tunisia. An established global energy player with gas transmission to Europe (cf. *Appendix 7*), the country started to look into solar power much earlier than its North African neighbors, driven by the interest to replace gas-fired power plants with solar so as to free up more natural gas for exports. Algeria is far ahead of its neighbors on the path to capitalizing on its comparative advantage in solar energy:[31]

- It introduced a feed-in tariff for hybrid power (gas and solar) in 2004[32]
- It established a non-binding target of generating 5% of its electricity from renewable sources by 2015 and potentially 30% by 2050. A state agency, New Energy Algeria (NEAL), was set up and tasked with achieving these goals.[33]
- The 150MW Hassi R'Mel hybrid plant is due to begin operations in October 2010 (ahead of Morocco's Ain Beni Mathar or Egypt's Kureimat project);
- Following completion of Hassi R'Mel, NEAL plans to build 400MW of additional solar power facilities at Mghaier (east) and Naama (west);
- In November 2009, state-owned utility Sonelgaz announced an impending bidding round for a $100 million solar cell panels factory scheduled to open by 2012.
- Algeria's largest private energy company, Cevital, joined the DESERTEC initiative in July 2009 long before any other MENA company.

While Algeria is the North African leader in solar energy, it is nowhere as keen to cooperate with Europe on solar energy as Morocco or Tunisia. Its centralized and closed economic structure and its deeply historic skepticism about relations with Europe go a long way in explaining this more disengaged stance. Faced with a projected average annual increase in electricity demand of 7% over the next five years,[34] the Algerian government is keen to keep full control over the development of solar energy on its territory. Algeria's minister of energy and mines, Chakib Khelil, has termed the

DESERTEC plans as "not concrete" and stated that his country would only participate "if (its) conditions are met". [35]

Nonetheless, progress is taking place: Following an audition of the Energy and Mines minister on September 6, 2009, President Bouteflika decided to hasten the creation of a special fund dedicated to renewable energy with a focus on solar power.[36] The Observatoire Méditerranéen de l'Energie (OME), an association representing the leading Mediterranean energy companies in which Algeria has an influential voice, is reportedly playing an increasingly vocal role in promoting the DII.[37] In short, Algeria is not categorically opposed to trans-Mediterranean trade in solar energy, but it has endorsed the concept much less clearly as Morocco and Tunisia.

In essence, the keenest partners in North Africa – Morocco and Tunisia – are trailing behind in their renewables policy, while Algeria, the country with the biggest solar potential, is most detached at this point. A major challenge going forward will, thus, be to create incentives for Algeria not to stay "out of the game" but rather to join a broader Mediterranean framework. Primarily based on hydrocarbons so far, the EU-Algeria strategic energy partnership renewed in 2006 could prove a useful forum in that regard.

IV. HOW EUROPE SHOULD THINK ABOUT THE PROPOSAL

Trans-Mediterranean cooperation on solar energy is not an end in itself. It should not be pursued for purely political or humanitarian reasons. Ultimately, it only represents one strategy among others towards the EU's two key interests in the field of climate change and energy policy, which are to:

- Minimize CO^2 emissions from electricity generation;
- Maximize energy security.

The European Union will and should only push for trans-Mediterranean trade in solar energy if it believes that the proposal represents a sensible strategy towards the achievement of these key interests – just as North African stakeholders will only pursue the proposal if it helps further their key interests, which are to:

- Develop economically by capitalizing on the comparative advantage in solar energy;
- Meet burgeoning electricity demand.

The combination of excellent solar irradiation and boundless space in North Africa is so unique that the region will be home to one of the world's biggest solar potentials for as long as we use solar technology. Adding this potential to Europe's domestic renewable energy potential would allow renewables to gain real scale in the European energy mix, promising great progress towards the de-carbonization of our economies. Regarding energy security, the proposal is promising as well: it would diversify Europe's energy mix, the range of countries from which it imports, and the import routes.

In short: the potential is great, and maybe trans-Mediterranean trade in renewable energy will be a useful policy towards de-carbonization and energy security – but maybe not. There are plenty of alternative policy strategies or changing circumstances that could render trans-Mediterranean trade in solar energy unnecessary, amongst them the following:

- Domestic renewable energy potential proves sufficient;
- A major technological breakthrough eradicates the need for solar energy;
- Nuclear technology becomes the privileged strategy of most Member States;

- Carbon Capture and Sequestration (CCS) proves cheaper and safer than expected;
- Other energy trade partnerships are prioritized (e.g., Russia, Caucasus, Iran);
- EU policies of climate change mitigation lose in priority.

These alternatives differ greatly in terms of likelihood, economic merit, adverse effects, and political feasibility – policymakers will have to decide about the optimal combination of policies to achieve Europe's interests. This study does not intend to aid policymakers in this process. Rather, it approaches the proposal of trans-Mediterranean trade in solar energy as one of many policy options and suggests the following approach for European strategic thinking on the topic.

European strategic dialogue should:

1. Acknowledge the **potential** of trans-Mediterranean trade in solar energy for climate change mitigation and energy security;
2. Acknowledge that there is no silver bullet for progress on these key interests, and that a combination of policies is needed, which **might include trans-Mediterranean trade** in solar energy;
3. Accept that trans-Mediterranean trade in solar energy faces numerous barriers and is **not yet an actionable policy option**;
4. Accept that some **political work and expense is required** in order to turn the proposal into an actionable policy option;
5. Determine how much it would **cost** in terms of political work and expense to sufficiently lower the barriers to turn the proposal in to an actionable policy option;
6. Decide about Europe's **willingness to pay this cost** in order to reach the point at which a choice can be made about whether or not to develop trans-Mediterranean trade in solar energy.

The following chapters seek to determine the amount of sunk cost that Europe must be willing to face by isolating those barriers that are truly dependent and uniquely related to the proposal of trans-Mediterranean trade in solar energy, and disaggregating them from independent and overestimated barriers.

V. INDEPENDENT BARRIERS

Having established the status quo as well as the analytical framework with which this study approaches the North African and European perspectives on the barriers to trans-Mediterranean trade in solar energy, this chapter will identify the first set of barriers. These are the *independent* barriers – those that the EU and its Member States are already working on and will continue to work on even if the proposal of trans-Mediterranean trade in renewable energy is not pursued; namely, the high cost of renewables, ineffective electricity transmission within the EU, and insufficient market integration and policy harmonization within the EU.

Barrier #1: High cost of renewable energy

a. EU is a leader in renewables R&D

Renewable energy has been a highly visible topic in Europe for many years – both publicly and politically. The EU has the world's most ambitious agenda for rolling out renewables, but still, they only accounted for 7.8% of Europe's gross domestic energy consumption in 2007.[38] Cost is undoubtedly the leading cause of this imbalance between ambition and reality: renewables are still too expensive compared to alternatives and will not be deployed at dramatically higher scale unless this cost differential drops substantially.

The EU and its member states are fully aware of the cost barrier and have been pouring substantial funds into R&D of renewable energy technology. Investments dedicated to R&D in non-nuclear low-carbon technologies amounted to €2.38 billion across the EU in 2007, of which 70% came from the private sector.[39] In a nutshell, the European Union is home to a big network of research institutions with large budgets that fund a flurry of R&D activity aimed at bringing down the cost of renewable energy.

b. … but not in those technologies best suited for North Africa

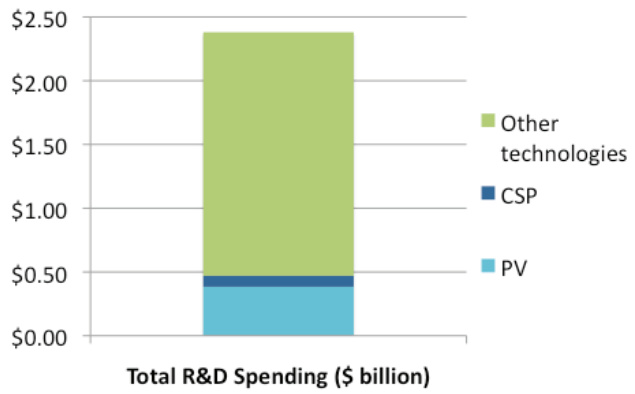
Research funding on renewables in the EU is focused primarily on technologies "that have widespread deployment potentials across the EU".[40] These are not necessarily the same as the technologies best suited for deployment in North Africa.

In the category of solar technology, photovoltaic (PV) is suitable even in places with little solar irradiation like the European continent. The other type of solar technology, concentrating solar power (CSP), requires very high irradiation and therefore holds little potential for deployment in Europe. North Africa, on the other hand, lies within the sun-

belt between +/- 35° latitude, where CSP currently seems to be the best solar technology for utility-scale electricity generation. Therefore, it seems likely that CSP will be the big player in renewable electricity generation in North Africa for the time being.

Disaggregating spending on R&D between the technologies yields a less promising picture: Across the EU, PV receives much more research funding than CSP: €384 million for PV and only €86 million for CSP. *Figure 7* below summarizes the EU's R&D spending on the priority technologies of the Strategic Energy Technology Plan (SET-Plan):

Figure 7. **R&D spending in the EU on carbon-free energy technologies**



Source: European Commission, *Investing in the Development of Low Carbon Technologies (SET-Plan)* SEC(2009) 1296

These figures indicate clearly that the technology with the highest potential for deployment in North Africa receives only dismal amounts of R&D spending within an otherwise extensive R&D agenda. Furthermore, this limited R&D is concentrated in only three countries: Italy, Spain, and Germany account for 95% of all R&D activity on CSP technology.[41]

In conclusion, current R&D on renewables in the EU is ambitious but gives too little attention to technologies that seem most suitable for deployment in North Africa for the time being.

Barrier #2: Ineffective Electricity Transmission within the EU

a. EU networks in need of serious upgrade

Any large-scale rollout of renewable energy – whether it included North Africa or remains domestic to the EU – will require an upgrade of electricity transmission infra-

structure within the EU. To echo the EC's 2008 Green Paper, the EU simply will not be able to deliver on its climate and energy goals "without new and improved networks."[42] In that, ineffective electricity transmission constitutes an *independent* barrier; one that is critical to the EU, irrespective of whether or not trans-Mediterranean cooperation in renewables is pursued.

Current deficiencies lie both in the European landscape of regulators and in the state and sophistication of Europe's transmission networks, last overhauled in the 1970s with the start of the nuclear era.

b. Towards smart grids

A system of electricity generation in which renewable energy plays a leading role is necessarily decentralized and requires a particular transmission network. Europe's current grid remains to a large extent inflexible – oriented towards the needs of centralized power generation in base-load plants. All leading technical reports point out that a substantial share of renewables requires a "smart" grid that can manage and calibrate decentralized power generation according to local demand,[43] and a "super" grid that connects demand centers with stochastic supply[44] through long and efficient high-voltage direct current (HVDC) transmission lines.[45] Upgraded, "smarter" grids could handle an energy supply system where renewables take a share of 90% by 2050.[46]

Current European transmission networks fail to display the sophistication, reach, interconnectedness, and flexibility necessary to accommodate renewables at large scale.[47] Beyond the mere addition of physical cables and interconnections, the main challenge remains the promotion of flexible, integrated management and regulatory systems at the EU-level.

c. Status quo and ongoing initiatives

Constructing high-voltage transmission lines between countries is expensive, takes time, and often meets fierce political opposition. Furthermore, power infrastructure – and electricity in particular –has so far remained the prerogative of national governments. This has largely held back efforts to further integrate grid management at the European level. Recognizing the evident hindrances in terms of efficiency, cost-effectiveness, and supply-reliability consequent to such infrastructural and operational deficit, the EC has begun tackling the issue.

There is indeed wide recognition within Europe that the main instrument for EU transmission development, TEN-E, is no longer suited or adequately funded to tackle today's energy challenges.[48] Following the October 16, 2008 European Council calling on the Commission to "reinforce and complete critical (energy) infrastructures", the EC started the process of devising a comprehensive strategy in cooperation with national and regional authorities and market actors.[49] Among several decisions, four in particular appear critical to the future of EU electricity infrastructure:

- Creation of European Network of Transmission System Operators for Electricity (ENTSO-E) (operational ahead of schedule);
- Creation of Agency for Cooperation of Energy Regulators (ACER) (due to be operational by March 3, 2011);
- Draft EU Parliament resolution requiring MS to report energy investment projects;
- Announced €0.9 billion EC funding for 12 electricity transmission projects.

The success or failure of these initiatives will largely determine how far the EU will manage to lower this independent barrier.

d. Recent developments

On February 25, 2010, the EU parliament passed a draft regulation requiring Member States to notify the EC every two years about energy investment projects (including electricity transmission) concerning the "building, modernization, and decommissioning of energy capacities."[50] Such dispositions would first, enable more efficient EU-level planning, the promotion of best practices, and the establishment of greater transparency for the benefit of market participants. Second, this would arguably allow the EC to better address Russia's "divide-and-rule" approach to energy politics in EU countries, especially regarding energy projects.[51]

The EC is currently producing an infrastructure package (potentially bythe end of 2010) investigating grid requirements and replacing the current TEN-E with "new instruments."[52] On March 1, 2010, ENTSO-E publicized a first circulation of its mandated "10-year network development plan" (due in June 2011) as a non-binding contribution towards the package. Total infrastructure needs were presented as follows: 35,000km of new lines and upgrades of 7,000km of existing lines across 34 countries, for an estimated €23-28 billion by 2015. On March 1, 2010 ENTSO-E also produced a policy response to ERGEG's position paper on "smart" grids, stressing the importance of reforms at the EU-level.[53]

On March 4, 2010, the EC announced an unprecedented €2.3 billion plan for energy infrastructure as part of the EU's €5 billion stimulus package. In addition to €1.4 billion allocated to 31 gas pipeline projects, it included €225 million for electricity interconnections between France and Spain, and €110 million for a new submarine cable between Sicily and continental Italy.[54]

Ineffective electricity transmission in the EU hinders market efficiency and the integration of renewables – whether they be sourced within Europe or from outside. It is a major issue that will require substantial reform and sizable long-term investments in infrastructure. The EC has clearly acknowledged this challenge and indeed has started taking action towards reforms, including important infrastructure financing commitments.

Barrier #3: Insufficient market integration and policy harmonization at the EU-level

Let us assume for a moment that cheap green electricity was available for import from North Africa and that sufficient transmission lines across the Mediterranean existed to allow for imports to Europe. Even if the cost and transmission barriers were overcome, utilities in Europe *could* and *would* not make use of this import opportunity as things stand: they could not because electricity markets are insufficiently integrated; they would not because many of them face perverse incentives and are in effect not looking for cheap import opportunities of green electricity.

a. Utilities could not import: Insufficient integration of electricity markets

Not only are offshore wind parks, the large hydro potential of Scandinavia and the Alps, and regions of strong solar irradiation in southern Europe quite distant from one another, they are also situated far from the centers of electricity consumption. Only trade in green electricity between these regions, on integrated markets, can help Europe maximize the share of renewable energy. In addition, energy market integration promises tangible economic benefits: the European Commission estimates that "further progress on integrating the European energy market could add an extra 0.6% to 0.8% to the bloc's GDP."[55] Reason enough for the European Union to push towards integrated electricity markets.[56]

An integrated European electricity market is an old aspiration of the EU, but to this day, electricity markets remain national or regional at best. Resistance to integration has been staunch and is "only slowly being overcome."[57] Two groups have been able to exert sufficient pressure on member state governments to halt progress: utilities and renewable energy lobbies.

Most utilities in Europe evolved from monopolistic energy providers and continue to defend privileges and prerogatives from that era, fearing competition over their costumer base as a result of integrated European electricity markets. The renewable energy lobby is skeptical about market integration because it fears that utilities would import cheaper green electricity from abroad instead of investing in more renewable energy capacity domestically. For example, the German solar lobby fears that market integration could allow utilities to import solar energy from southern Europe, where more sunny days and higher solar irradiation lead to significantly lower prices.

The EU has held steady against this resistance but progress towards integrated electricity markets is slow. The Renewable Energy Directive of 2008 with its 20-20-20 targets represents one step in the right direction, as it introduced mechanisms that amount to trade in renewable energy between Member States.[58] In any case, the Renewable Energy Directive is to be understood as a first step: it does not solve all the trade barriers in renewable energy. Utilities all over Europe would need much more specific legislative and regulatory guidance from the EU and their respective governments in order to embark on complex transactions such as, for example, solar electricity from Morocco being imported by a Belgian utility and transmitted through Spain and France.

In short, market integration within the EU remains a work in progress and does not yet allow for the complex transactions that would be required to import green electricity from North Africa to Europe, but the EU is committed to work on this barrier independently of the proposal of trans-Mediterranean trade in renewable energy.

b. Utilities would not import: perverse incentives in national support schemes

In order to illustrate this barrier, let us assume again that cost and transmission would not be a problem, and furthermore that sufficient regulatory and legislative groundwork existed so that a utility anywhere in Europe could import green electricity from North Africa. Even in this case, many utilities would not want to do it, because it would not help them achieve their goals.

Some Member States in the EU support renewable energy with schemes that aim to maximize the share of renewables in the electricity mix. For example, quota systems or renewable energy portfolio standards force utilities to source a specified percentage of their electricity from renewables. Utilities facing these quantity-based incentives are thus looking for the cheapest green electricity on offer, and could be very interested in importing from North Africa.

The support mechanisms of other Member States, however, do not aim to maximize the percentage of renewables in the energy mix but rather the total amount of re-

newable energy generated domestically. Most commonly, feed-in-tariffs force utilities to pay a fixed price per kWh to anyone who connects green electricity to the grid. Utilities facing these price-based incentives have nothing to gain from importing green electricity: they receive green electricity, pay the feed-in-tariff, and pass the cost on to consumers, without having an interest in sourcing the cheapest renewable energy themselves.

This structural difference between quota systems and feed-in-tariffs means that many utilities in Europe face perverse incentives that would cause them to turn down an attractive opportunity to import green electricity from North Africa. Even independently from this proposal, the EU has been conscious of the substantial differences between the support schemes of its Member States for years, and actively supports their harmonization.

VI. DEPENDENT BARRIERS

The *independent* barriers analyzed in the last chapter are of course substantial but in reality they must be disaggregated from the proposal of trans-Mediterranean trade in solar energy because they are being engaged for independent reasons. In other words, all the political and financial capital spent on lowering these independent barriers will have come to good use even if the proposal of trans-Mediterranean trade in solar energy is never realized.

A second set of barriers on the other hand is truly *dependent* and uniquely related to the proposal of trans-Mediterranean trade: actions to lower them would not be required, were Europe to decide against pursuing the proposal. However, Europe will not even reach the position to make this decision, unless it lowers the dependent barriers sufficiently for the proposal to become actionable. In essence the sum of actions, required to sufficiently lower the barriers identified below, represents the sunk cost that Europe must be willing to face to arrive at the position to decide on the proposal of trans-Mediterranean trade in solar energy.

In this light, the dependent barriers are the most important of them all; namely: insufficient clarity regarding technology, high cost of renewables specifically in North Africa, lack of substantial trans-Mediterranean transmission, and inadequate legal and commercial frameworks in North Africa.

Barrier #4: Insufficient clarity regarding technology

a. Renewable energy technology an open race

As was explained in the introductory section on methodology, the proposal of trans-Mediterranean trade in renewables of course applies to all forms of renewable energy, but above all, solar energy promises substantial scalability in North Africa. Furthermore, it has been pointed out that CSP technology as opposed to PV seems to be the most promising solar technology for utility-scale electricity generation in North Africa. While these assumptions are helpful in focusing attention on the biggest moving pieces, they should in no way distract from the fact that substantial uncertainty about technological questions remains.

Open questions regarding technology are currently a major cause for investors' hesitancy Fearing that their technology variant might prove to be a dead-end , investors shy away from being the pioneers in building solar plants in North Africa. The race in solar energy technology is not one of price competition within a single product category, but rather a competition between many different technological variants. Cost, and intermittence of the generated electricity are the main criteria of this competition.

Product development in PV technology is currently extremely dynamic, especially since China has become both a vast market for photovoltaic cells and home to very strong PV companies. Variants such as thin film and concentrating photovoltaics are currently receiving particular attention. While many experts doubt that the PV industry will manage to present products in the immediate future that are suitable for utility-scale electricity generation in North Africa, it was noted with great interest that a global leader in PV technology from the United States – First Solar – joined the DESERTEC consortium as an Associated Partner in March of this year. Furthermore, the Chinese government has remained a steadfast believer in PV technology, and many independent experts in solar R&D agree that PV should not be written off for utility-scale use.

In a nutshell, solar energy technology remains in a volatile state and no consensus on optimal variants for utility-scale power generation has yet emerged. This uncertainty must be overcome to an extent sufficient for the investors to make more calculable decisions about such large-scale and long-term investments.

b. Far too little experience with different technologies of CSP

While developments in PV remain dynamic, the race between technological variants within the other type of solar technology, concentrating solar power (CSP), is at an even earlier stage. While CSP technology is not new – the first CSP plants of considerable size were built in the early 1980s – only a total of 12 plants are in existence all over the world. They amount to a total installed capacity of only 560 MW by mid-2009,[59] compared to 15,200 MW of PV. In other words, CSP technology currently plays a negligible role in global power generation. However, the sector has become more dynamic in recent years. Installed capacity is set to triple with plants already under construction. Another 7,463 MW have been announced in development, mainly in the United States.[60] CSP technology is, thus, likely to reach substantial installed capacity by the end of the decade, which, for the first time, will allow for wide comparison between sites and technologies.

Currently, installed capacity and plants under construction are heavily focused on one of the four leading types of CSP technology: mirrors arranged in a parabolic trough that reflect the sun onto a tube receiver that runs along the focal point of the trough.

Parabolic trough

Tower

Fresnel

Dish

TECHNOLOGY TYPE	INSTALLED CAPACITY 2009 [MW]	ELECTRICITY PRODUCED UP TO 2009 [GWh]	APPROXIMATE CAPACITY, UNDER CONSTRUCTION AND PROPOSED [MW]
Parabolic trough	500	>16,000	>10,000
Solar tower	40	80	3,000
Fresnel	5	8	500
Dish	0.5	3	1,000

Source: Greenpeace International, SolarPACES, ESTELA, Concentrating Solar Power – Global Outlook 2009, p. 18.

The other types might offer advantages over parabolic trough technology but have not yet been deployed at scale. Overall, the two most important technological questions are storage, cooling, and the use of CSP for water desalination.

The main advantage of CSP technology, for the purpose of utility-scale deployment in North Africa and potentially for export to Europe, is that the heat produced can be stored so as to continue electricity generation at night when the sun is not shining. This allows CSP plants to offer base-load electricity and sets it far apart from the intermittent technologies of PV and wind. However, no clear technological winner of **storage technology** has emerged. A number of technologies are being tried but deployment has been too small to allow for substantial learning effects.[61]

Aside from storage, the problem of intermittence can also be addressed by combining a CSP plant with a second unit that burns gas or coal. The fossil fuel combustion engine would then generate electricity when the sun is not shining. Such **hybrid plants**, called Integrated Solar Combined Cycle (ISCC), are especially attractive in countries with abundant gas deposits such as Algeria and Egypt. However, this approach has not yet been demonstrated at scale, and only seven hybrid plants are currently being constructed or planned. Many experts have noted that hybrid plants could function as a bridge technology while pure CSP plants are optimized and become economical.[62] In the absence of a larger deployment and use of this technology, however, reliable cost figures and valuable experiences are difficult to derive.

One of the main concerns over the proposal to construct CSP plants in North Africa is **cooling, and the associated need for water**. Like all thermal power plants, CSP plants reach their maximum efficiency if the steam that runs through the turbine is later condensed back to water using a cooling technology. The highest efficiency is achieved when water is used to cool the steam. However, evaporative or wet cooling, as this technology is called, consumes a lot of water, which is of course unsustainable in the Sahara desert, where water is very scarce and precious. CSP plants that use dry cooling, however, generate electricity with less efficiency, which means that they produce at a higher cost per kWh than plants that can rely on wet cooling.

As such, finding cheap and efficient methods of dry cooling is essential for the future of CSP in North Africa. Alternative cooling technologies exist, such as hybrid cooling or Heller systems, but they need to be tried and tested, at scale and on site in North Africa, so that scientists and industry can develop a framework that allows for the optimization of efficiency against water consumption across a wide variety of sites.

A major technological question concerns the idea that CSP plants in North Africa could also be used for **seawater desalination**. As the MENA region harbors serious concerns about water access going forward, this possibility could give an extremely strong impetus to massive deployment of CSP in the region. An extensive study by the German Aerospace Center analyzed this idea and concludes that the potential is both immense and realistic.[63] However, the idea remains theoretical – a pilot project is wanting.

In conclusion, the open questions regarding solar technology are numerous and important. The answers could fundamentally alter the way we look at solar energy and its potential south of the Mediterranean. No large-scale deployment strategy would make sense before more of these questions are resolved. This resolution cannot happen in laboratories around the world alone, however. Many technological questions are site-specific and must, therefore, be addressed on site in North Africa itself.

Barrier #5: High cost of renewable energy specifically in North Africa

a. Cost of renewables remains an important and complex barrier

Comparative cost calculations of renewable energy are inherently complex because they are determined by myriad factors.[64] Nonetheless, it is safe to say that the high cost of renewable energy technology remains a central if not the highest barrier of them all. If green electricity from the Sahara was so much cheaper than anything else, the impetus to overcome the other barriers would be much larger than what we see today.

Reliable data for cost estimates in the region is very rare. As of now, the only site-specific cost calculations are academic papers, the best of which were written in 2005[65] and 2008.[66] Much groundbreaking activity has occurred in the field since then. Currently, a number of CSP plants and other renewable generation capacity are being installed in North Africa and the Middle East, however, it will take time until these plants can provide reliable cost data. The DESERTEC Industrial Initiative (Dii) has announced that it will present a comprehensive financial analysis in 2012, which is sure to meet great interest – both from circles of industry and policy.

b. How to think about the price of renewable energy from North Africa

All thinking about the cost barrier must begin with the general principle that renewables will only be rolled out at scale in North Africa if they are cost competitive on the domestic market, on the European market, or ideally on both.

On the domestic market, price is the deciding factor. North Africa's economic development priority requires cheap electricity tariffs and as the countries have very low CO_2 emissions per capita, there is little pressure to make electricity-generating capacity green. Renewables, therefore, compete with all technologies on the domestic markets, even with coal and North African gas without carbon capture and storage. On the European market too, cost is an important consideration. Nonetheless, policy of the EU and of its Member States is designed to maximize the share of green electricity, even if it comes at a moderate price premium.

So what is the appropriate alternative that we should compare to the cost of renewables from North Africa on the European markets? Critical voices suggest that imported electricity from North Africa would be competition to domestic renewable energy. This notion is mistaken and misguiding: the EU and its Member States have a declared incentive to maximize energy security and domestic renewable energy capacity. They are sure to guarantee that green electricity imports from North Africa do not replace domestic renewables but rather complement them in replacing carbon-intensive generation capacity.

Green electricity from North Africa, therefore, must not be cheaper than the output of carbon-intensive coal or gas plants in Europe; rather, it must be competitive with domestic carbon-neutral technologies, such as coal with CCS, domestic wind, solar, and nuclear energy.

c. Renewables not yet competitive on domestic markets in North Africa

Renewable energy technologies are currently nowhere near cost competitiveness in North Africa, as *Figure 8* below indicates.

***Figure 8*. Cost comparisons on the domestic markets of North Africa**

On domestic market	Levelized cost in US c/kWh
CSP with storage	12-14[1]
Photovoltaic (PV)	20-40[2]
Wind	5-12[2]
Coal without CCS	7-8[1]
Gas	2-7[1]
Nuclear	6-9[3]

[1] Center for Global Development: *Desert Power: The Economics of Solar Thermal Electricity for Europe, North Africa, and the Middle East*, 2008
[2] Renewable Energy Policy Network for the 21st Century: *Renewables 2007 Global Status Report*
[3] Massachusetts Institute of Technology: *Update on the Cost of Nuclear Power*, 2009

As mentioned before, CSP is currently deemed to be the more cost-efficient solar technology for deployment in North Africa. However, with only a few CSP plants under construction in North Africa and the Middle East until now, estimates of levelized costs of CSP in the region are rare and have a substantial variance. The Mediterranean Solar Plan of the Union for the Mediterranean estimates an average cost of 21.6 c/kWh.[67] The most detailed and site-specific studies available indicate that this estimate is quite conservative. CSP plants in North Africa are here estimated to be able to produce at a levelized cost of 12-14 c/kWh excluding transmission.[68]

Wind energy suffers from intermittence and can achieve low cost of between 5-12c/kWh only on the Atlantic coast of Morocco and the Red Sea coast of Egypt. While its scalability is therefore limited, this wind potential is truly competitive and should be put to use. PV technology remains unable to dip below 20c/kWh even at sites with the best solar irradiation of North Africa and cannot currently provide baseload capacity due to the lack of electricity storage technology. As such, at present CSP is the cheapest technology of renewable energy that can be scaled in North Africa, even though it remains more than twice as expensive as the fossil fuel alternatives.

Coal only plays a role in Morocco and Tunisia, as they do not possess major gas deposits of their own. Nuclear remains an alternative that is being seriously considered all across North Africa. Algeria, Libya, and Egypt have abundant deposits of natural gas, and each of these countries subsidizes natural gas heavily for domestic consumers, industry, as well as utilities. Resultantly, it is impossible to compete with natural gas for electricity generation under current market conditions in North Africa. Even in countries such as Morocco and Tunisia, imported natural gas from their North African neighbors is mostly priced to undercut alternative fuels and technologies. As long as the governments of the region sustain their subsidies, it will be very difficult to avert a future in which North Africa meets its burgeoning energy demands almost exclusively with fossil fuels.

Will gas-exporting nations like Algeria and Egypt lower their gas subsidies? In recent years, awareness has developed that subsidies cause wasteful consumption of a valuable resource endowment. Governments are looking for ways to replace gas-fired electricity plants with alternative technologies to free up gas for export. However, they face a conundrum: as long as generous gas subsidies persist, all other technologies cannot compete on price. This cost differential can only be closed in two ways: one would be to redirect subsidies from natural gas to its alternatives, but this would erode the very savings that the shift from gas to alternatives is aimed to capture. The only other option is to decrease gas subsidies for utilities. This would cause a substantial appreciation of national electricity tariffs and fierce political opposition. Judging from past experience, few governments will face these pressures – North Africa's reliance on subsidized natural gas is, therefore, likely to persist, making it difficult for renewable energy to compete.

Natural gas subsidies in North Africa do not just artificially lower the price of natural gas, they also stabilize it: subsidized natural gas in North Africa is decoupled from the export price. In effect, not even a substantial increase of natural gas export prices would make renewables more competitive.

In conclusion, CSP or other renewable technologies must become as cheap as 5-8 c/kWh in order to compete with natural gas unless the gas-rich countries of North Africa embark on fundamental reforms of their electricity markets by phasing out subsidies for natural gas and electricity.

d. More competitive on European market, but not cheap enough yet

On the European market, the cost differential is much smaller, as *Figure 9* below illustrates.

***Figure 9*. Cost comparisons on the European market**

On European market	Levelized cost in US c/kWh
CSP from North Africa with storage	12-14[1] + 2-3 for transmission[6]
CSP in Europe with storage	15-25[2]
Photovoltaic (PV)	30-80[3]
Wind	5-12[3]
Coal with CCS	4-8[1] + ~3 for CCS[4]
Gas with CCS	9[1] + ~3 for CCS[4]
Nuclear	6-9[5]

[1] Center for Global Development: *Desert Power: The Economics of Solar Thermal Electricity for Europe, North Africa, and the Middle East*, 2008
[2] Greenpeace International, SolarPACES, ESTELA*: Concentrating Solar Power – Global Outlook 2009*, p. 33
[3] Renewable Energy Policy Network for the 21st Century: *Renewables 2007 Global Status Report*
[4] German Aerospace Center DLR: *Concentrating Solar Power for the Mediterranean Region*, 2005, p. 124
[5] Massachusetts Institute of Technology: *Update on the Cost of Nuclear Power*, 2009
[6] Stiftung Wissenschaft und Politik (SWP): *Solarstrom aus Nordafrika. Perspektiven und Rahmenbedingungen*, 2010, p. 26

While CSP is projected to produce at 12-14 c/kWh in North Africa, the best performing Spanish plants at the best sites in Europe currently produce at 15c/kWh.. Many other sites in Spain have levelized costs as high as 23 eurocents/kWh. In principle, good sites in the Sahara desert promise 20-30% less cost than the best sites in southern Europe, because solar irradiation here is around 20-30% higher (2,600-2,800 compared to 2,000-2,100 kWh/m^2 per year).[69]

The cost of transmitting green electricity from North Africa to Europe must of course be added to the generation cost to derive a cost figure comparable to domestic alternatives. Folding transmission costs into generation cost is quite difficult for many reasons.[70] Furthermore, very few comparable transmission lines exist for reliable cost estimates.[71] As a general indication, we assume transmission cost of 2-3 c/kWh for transmission between sites in North Africa to central Europe.[72] As a result, we estimate that CSP from North Africa would compete at around 14-17 c/kWh on European markets.

Wind has reached competitive cost in Europe, but its scalability remains limited due to its intermittence and increasing siting challenges. PV suffers from intermittence and the low solar irradiation of Europe, making it even less cost-competitive than in North Africa.

Aside from comparing the cost of North African renewables to domestic CSP, PV, wind, and other renewables, we must draw cost comparisons with other carbon-neutral technologies like nuclear and carbon capture and storage (CCS). CCS is nascent and awaits testing at utility-scale. Current estimates of what it would cost to store CO_2 and to install carbon capture technology in new coal and gas plants or to retrofit existing ones roughly predict a marginal cost of around 3 c/kWh.[73] This would yield a cost of around 7-12 c/kWh for carbon-neutral coal and gas in Europe.

In conclusion, green electricity from North Africa must reach around 7-12 c/kWh including the cost of transmission to be cost competitive with all carbon-neutral technologies on the European market.

d. Learning curve: cost differential is surmountable

These cost estimates are undoubtedly crude, but they carry the essential conclusion about the cost barrier. As *Figure 10* below illustrates, the cost differential is still considerable in Europe and even more pronounced in North African markets: even the cheapest renewable technology (CSP) would have to drop by another 2-10 c/kWh to be competitive both domestically and for export to Europe.

Figure 10. **Cost differentials of CSP and alternatives on domestic and European markets**

	Domestic market	European market
Cost of alternatives	2-7 c/kWh	7-12 c/kWh
CSP from North Africa	12-14 c/kWh	12-14 c/kWh + 2-3 for transmission
Cost differential	**~ 4-10 c/kWh**	**~ 2-10 c/kWh**

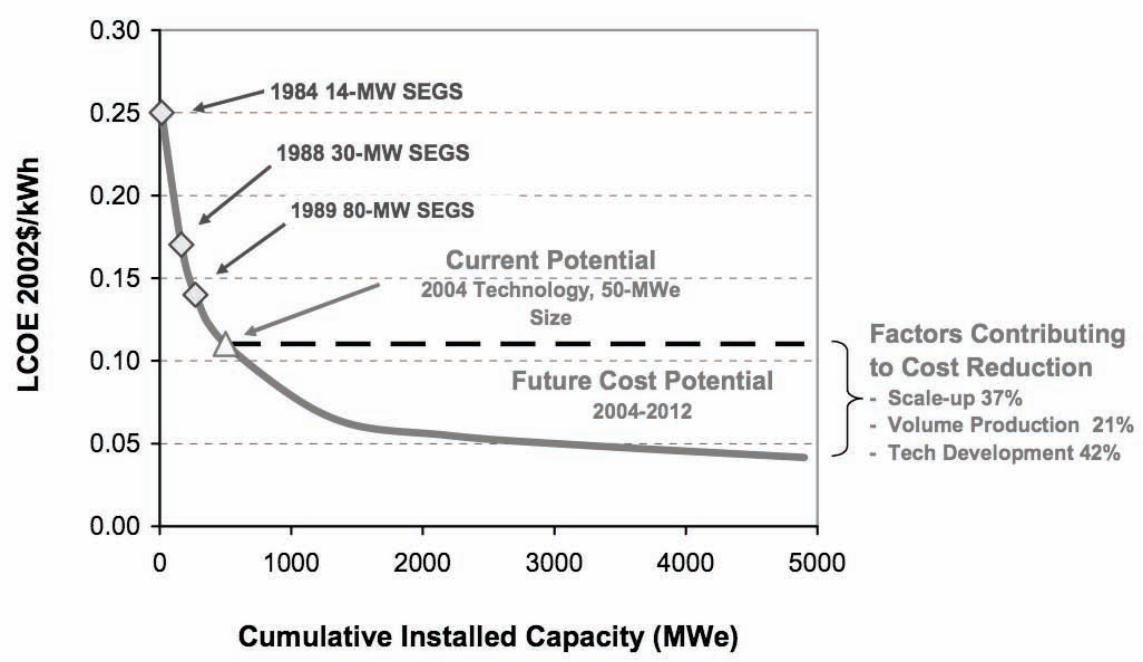
Source: Authors, see previous two tables.

Here it must be reiterated that the technology race remains open: It is entirely possible that breakthroughs in PV or storage technology cause PV to leapfrog to the low costs of CSP and wind. However, the technology that currently seems most likely to reach competitiveness at scale in North Africa is CSP. That is why the remainder of this chapter will focus on CSP technology when analyzing how the cost barrier could be overcome.

All energy technologies experience what is called a "learning curve": as more capacity is installed, learning effects and economies of scale cause costs to fall. *Appendix 6* illustrates learning curves of different energy technologies in the EU in the 1980s and 1990s. Time alone does not drive costs down. Rather, it is the cumulative amount of electricity generated using a certain technology, which is a function of the total amount of installed capacity of that technology. In conclusion: cost will only come down when substantial capacity is installed.

How steep is the learning curve of CSP technology, and where on the curve do we find ourselves at the moment? These are questions involving some contention because the low number of CSP plants worldwide yields few data points. All major studies agree that costs of CSP will continue to decrease as more capacity is installed. There are however disagreements about how steep this curve will be.[74] *Figure 11* below illustrates one of the most commonly cited estimates.

***Figure 11*. Learning curve of CSP**



Source: US Department of Energy: *Report to Congress on Assessment of Potential Impact of Concentrating Solar Power for Electricity Generation*, 2007.

This estimate stems from a study by an independent engineering firm commissioned by the US Department of Energy, and got validated by the US National Research Council. It predicts that levelized costs would drop to a vey competitive 6 c/kWh once installed capacity totals around 2000 MW and below 5 c/kWh at 5000MW installed capacity.

It is very likely that the learning curve will not be this steep in reality. The 2009 White Paper of the DESERTEC Foundation expects that the installation of 5000 MW (5 GW) would cause cost to drop from 14-18 c/kWh to 8-12 c/kWh, and that costs of 4-6 c/kWh would be reached after a substantial rollout of 100 GW. Currently, less than 500 MW are installed, but 5000 MW in new capacity are already under construction or development. The generation of plants following the learning effects of these first 5 GW of installed capacity, promises to be able to generate at much lower cost.

As indicated in *Figure 11* above, the factors that are going to contribute to the fall in prices are technology development, scaling-up the size of individual plants from under 50 MW to well above it, and the mass production of components as supply meets increasing demand. The CSP industry shares this expectation.[75] While the power block including the steam turbines is mature technology, the innovative parts have the main cost reduction potential: mirror materials, the solar field, and the thermal storage system.[76]

These areas of cost reductions are mostly the same from one site to another. Other areas of potential cost reductions, however, are entirely site-specific, including the solar irradiation, site topography, transmission and grid connection, water availability, local infrastructure, risk premiums, and others. In effect, certainty about future costs of CSP from North Africa cannot be gained simply by sitting tight and waiting for learning effects from CSP deployment in Spain or the United States. Only plants in North Africa will generate reliable data on the falling cost of electricity generated by CSP plants in the region.

In conclusion, we note that the learning curve of CSP is hard to estimate, but that some of the most respected studies expect CSP to drop to competitive levels as 5000 MW of new plants are coming online. However, we will remain in the dark about the site-specific costs in North Africa until substantial capacity is installed in North Africa itself.

Barrier #6: Lack of substantial trans-Mediterranean transmission

The lack of Mediterranean transmission hinders trans-Mediterranean solar cooperation by physically preventing the electricity produced in North Africa to reach Europe. It is the project's most obvious *dependent* barrier, although not the simplest to take on.

a. Only Gibraltar for now

Contrary to gas transmissions (cf. *Appendix 7*), electrical connections between North Africa and Europe are rare. The main one was initiated in 1997 by the construction of a 700 MVA, 400kV AC undersea line between Spain and Morocco via the Strait of Gibraltar. A second one followed in 2001 and a third is currently underway.[77] This connection is the only operational trans-Mediterranean electrical link and most of the flow remains North-South.[78]

A plan for a 1,000MW link between Tunisia and Italy (project El-Med) was initiated in 2003 but has been delayed since.[79] In addition, various feasibility studies have been conducted regarding other submarine interconnection projects: Algeria-Spain (2003; 1,000MW), Algeria-Italy (2004; 500-1,000MW), and Libya-Italy via Malta (current; two 500MW).[80] *Appendix 9* provides an overview of existing and potential trans-Mediterra-

nean electrical connections. It is nevertheless difficult to determine the true stage of advancement of the plans in question.

b. Subsea transmission is expensive, relatively new, and unnecessary for now

In addition to the general lack of experience with long HVDC transmission, two main reasons arguably account for the lack of trans-Mediterranean electrical connection: cost and European saturation.

Connecting North Africa to Europe through the Mediterranean would necessitate expensive submarine HVDC lines and converter stations on both sides, respectively priced at around €2 million/km (for a 400MW line) and €185 million a piece.[81] Transmission power losses would also occur: 3.3% per 1,000km and 0.7% per converter station.[82] Adding operation and maintenance costs of about 2% of the total project capital cost makes for a very expensive venture that few investors (high upfront investment costs) or utilities (higher tariffs) have been willing to consider. DESERTEC priced transmission for its project at around €45 billion; a figure that EU ministries estimate to be closer to €100 billion. Others have estimated the transmission costs of exporting Moroccan solar energy to Europe to be around €580 million (excluding maintenance).[83] Cost is clearly prohibitive.

The other major roadblock to trans-Mediterranean electrical connection lies in the EU's own inability to absorb more capacity. This is especially true considering that only one point of entry exists to date (i.e. Spain). National AC grids and interconnectors on the continent are saturated and little has been done to compensate recent peak power growth with new and improved infrastructure (cf. Section V, Barrier no. 2).[84] There is again great hope that ENTSO-E will be able to lead the way in such reforms. In fact, the 10-year network development plan acknowledged the Mediterranean super grid as a "long-term" project (i.e. post 2020) and put forth a HVDC connection between Sicily and Tunisia.[85]

The construction of added transmission between Europe and North Africa is ultimately contingent upon two things: first, decrease in the relative price of HVDC submarine lines and converter stations; second, ambitious EU infrastructure upgrade and electricity management improvement. In that, lowering Barrierno.6 directly depends on lowering Barrier no. 2 i.e.ineffective transmission within the EU (cf. *Appendix 10*). Until substantial and diffuse absorption capacity exists in Europe and capital costs of transmission have gone down, additional trans-Mediterranean electrical connections are unlikely to be built.

Barrier #7: Inadequate legal and commercial frameworks in North Africa

a. Green electricity and the laws that govern it – many open questions

Even if questions of technology were resolved, cost were competitive, and sufficient transmission lines across the Mediterranean existed to allow for imports to Europe, European investors would harbor concerns about constructing plants in cooperation with North African countries and companies because substantial doubts about the legal and commercial framework remain.

As has been noted before, renewable energy is entirely new to North Africa hence all laws and commercial mechanisms, that are to govern the deployment of renewable energy technology south of the Mediterranean, are new and largely untested – assuming that they exist at this point. What law governs investments in solar plans in North Africa? What rights do foreign companies have? Will North African states buy green electricity from these plants using a feed-in-tariff, or which mechanism will they use? Will these mechanisms be compatible with EU mechanisms, so that a single plant can make use of both domestic sales and exports to Europe? Substantial clarity and experience with such questions must be gained before financiers are sufficiently assured of legal safety and commercial success that projects become bankable.

b. Legislative framework: new laws, little experience

The most important groundwork is a renewable energy law. All North African states have passed one, with Morocco being the latest country to do so early this year. These laws all conform to the basic principles that govern renewables in Europe, and in fact the EU and its member states were often instrumental in advising the national governments of North Africa during the drafting of these laws. However, financiers will apply steep risk premiums until these laws have been tested in practice, until experience shows how they are enforced and defended in courts, and until gaps of the legislative framework have been filled and vague passages clarified.

Above all, an inviting legal and commercial environment in North Africa must allow European companies to become independent power providers (IPPs) in North Africa. This means that foreign companies are permitted to construct and operate power plants, to get guaranteed grid access, and to have the right to build their own transmission lines in order to connect to North African grids or to high-voltage transmission lines bound for Europe. Of course, it is preferable that companies from Europe and North Africa cooperate in joint projects, and this is in fact very likely. If a North African state forced such partnerships by law, however, it would raise serious concerns about investment climate and security. This concern is described in greater detail in Section VII, Barrier no.10.

Morocco and Tunisia have allowed IPPs for years and have made it clear in the language of their renewable energy laws that IPPs from abroad are an essential part in their respective strategies of pushing solar energy deployment. Algeria presents a different scenario: the Algerian Minster for Energy and Mines, Chakib Khelil, expressed interest in the DESERTEC project but quickly added that Algerian involvement would be conditional upon a dominant role of Algerian companies: "We don't want foreign companies exploiting solar energy from our land."[86]

European companies are absolutely willing to enter partnerships with North African companies, which is illustrated by the fact that the DESERTEC consortium now includes companies from Algeria and Morocco. However, excessively aggressive insistence on domestic dominance on the part of North African governments would not just set an adversarial tone, but could also produce a legal and commercial framework so restrictive, that it might derail any cooperation.

c. Commercial framework: Selling North African green electricity

In order to become bankable, every solar project in North Africa must be able to clearly predict future cash flows. How is the generated electricity going to be sold on the domestic market or on the European market? At first, these questions can be answered on an individual contract basis. A substantial rollout of renewables requires a more comprehensive commercial framework, however.

When discussing independent barriers in Section V, we mentioned already that the export of green electricity from North Africa to Europe requires further integration of electricity markets in Europe. Together, the independent barrier of market integration and the dependent barrier of a viable commercial framework describe the challenges of selling green electricity from North Africa in Europe.

EU's Renewable Energy Directive provides a first answer to this question: articles 9 and 10 of the Directive allow EU Member States to finance renewable energy projects in neighboring countries, for example in North Africa. Here, utilities from Europe would cooperate with North African companies or states on an individual project basis. North African authorities do not find sufficient clarity in these articles and are unsure of how transactions would work exactly. Indeed, the paradigm of individual contracts inherent in articles 9 and 10 fall far short of what is needed: a universal commercial framework that clearly structures how green electricity from North Africa can be imported by European utilities. What is the market, clearing floor, or mechanism for transactions? How are prices determined? What state support mechanisms apply? These and many more questions must be answered to form a comprehensive and viable commercial framework that would allow for European imports of green electricity from North Africa.

Regarding sales on the domestic market, the same questions apply. So far, only Algeria offers a clear framework- a feed-in-tariff for solar energy. Algeria offers the most advanced commercial and legal framework of the three North African states surveyed here. Morocco has announced that it wants to pour $9 billion into renewable energy infrastructure, setting itself the target to generate 38% of its electricity from solar energy by 2020. However, so far this remains declaratory: the target is non-binding, and it is entirely unclear where the announced $9 billion will come from. The Moroccan government has not set aside substantial funds of its own and seems to expect foreign donors to foot most of the bill. A comprehensive commercial framework for domestic sales is not in sight. The Tunisian Solar Plan, presented in December last year, does not amount to a comprehensive commercial framework. The country decided against instituting a feed-in-tariff, and so far resembles Morocco, in that its national strategy does not go far beyond a simple listing of desired projects.

In conclusion, much work remains for North African legislatures and regulators before large-scale deployment of renewable energy in North Africa becomes feasible. Comprehensive legal and commercial frameworks, both for exports to European markets and for sales on domestic markets, are needed. As experience leads to the extension and amendment of existing laws, the EU must make sure that the results are compatible with the legal and commercial framework that underlies the deployment and trade of green electricity in Europe. In this way, the investment security and commercial prospects can become strong enough to make projects bankable.

VII. OVERESTIMATED BARRIERS

Trans-Mediterranean solar trade is a complex, ambitious and somewhat controversial project engaging various transversal issues over a relatively long-term timeframe. As such, it is prone to Manichean considerations and condemned to be either wholly embraced or wholly rejected on potentially inaccurate or oversimplified grounds. While the concept of trans-Mediterranean solar trade certainly encompasses robust *independent* and *dependent* obstacles (cf. Sections V. and VI.), its discussion also features arguably over-estimated barriers – barriers that might be real and problematic *per se*, but not enough to really stand in the way of the realization of the concept. Four such barriers are analyzed below;

Barrier #8: Allegations of neo-colonialism

When the DESERTEC Foundation publicized its vision to meet 15% of Europe's electricity needs by 2050 through North Africa, certain commentators and public officials warned of a new blend of colonialism, or "eco-colonialism."[87] These critics expressed their opposition to what they saw as European firms taking control of the Sahara desert to produce — and send back — electricity, when North African populations face staggering needs of their own.

Interestingly, however, the staunchest opposition to any major solar rollout involving trans-Mediterranean cooperation arguably resides in Europe, with some echoes in the sub-Saharan African press.[88] Based on a review of various media, interviews with public and private stakeholders, as well as occasional conversations with locals while in North Africa, these allegations seem to be a phenomenon of primarily European public discourse. Energy policy in general, and solar energy from the Sahara in particular, do not stir public debate in North African countries. Electricity tariffs are a source of major public concern — and discontent — in North Africa; the state's strategic policy orientations are not.

Public opinion in Morocco, Algeria and Tunisia is either unaware of, or indifferent about, the project. More engaged actors such as local labor unions are more concerned with private sector hegemony in future projects than with alleged neo-colonialism. Among the people knowledgeable about the project, a consensus seems to exist around the idea that, should solar cooperation create jobs, improve training, facilitate technology transfers, and grow exports, it would be the better for North Africa and its population. In fact, the following question could be posed to North African decision-makers: would it make even greater economic sense for countries to maximize exports of solar energy to European markets and use the corresponding foreign exchange to meet local demand?

Finally, the concept of trans-Mediterranean solar trade has been largely co-opted by national elites in the three countries in question. It is fair to suppose that the rather autocratic or authoritarian nature of these regimes certainly accounts for the lack of major dissenting opinions in public discourse. In light of the state's relative control of the socio-political agenda in Morocco and Tunisia, major opposition to governmental orientations of such magnitude is very unlikely. Only the case of Algeria, where the government faces strong Islamic fundamentalist opposition (most notably, Al-Qaeda in the Islamic Maghreb), arguably has the potential to prove this supposition wrong.

Ultimately, allegations of neo-colonialism remain a largely over-estimated barrier when it comes to its actual capacity to obstruct the realization of trans-Mediterranean trade in solar energy. Solar cooperation could in fact contribute to improving the terms of Europe's perceived relationship with North African countries; one that is too often centered around controversial issues of immigration, security, and Islamic fundamentalism.

In order to make sure that Barrier no. 8 does not turn into a *dependent* obstacle, the EC should:

REC

State that its institutional support remains conditional on the project's addressing local electricity supply. The EC should nevertheless refrain from specifying a percentage of "dedicated" future production. It is not its prerogative and that number might not make any sense at this point.

REC

Stress the fact that North African countries indeed will experience **burgeoning electricity demand** in future years as **an argument in favor of the concept** and in fact a way to gain even greater local support for it.

REC

Use this opportunity to reframe the broader (perceived) neighborhood policy discourse: away from strict developmental and/or humanitarian assistance, and towards an economic relationship between equal partners engaged in trade, job creation, and technology transfers.

Barrier #9: Lack of regional integration

The lack of regional integration in North Africa is real and significant. It has plagued the region for a long time, reducing the scope for trade opportunities and preempting the gains of greater political unity. While this plight certainly constitutes a serious challenge to the sub-region, it arguably does not jeopardize the potential realization of trans-Mediterranean solar trade.

a. Several attempts,many failures

The strongest attempt at regional integration in North Africa was initiated in 1989 when the Arab Maghreb Union (AMU) was formed. Initially a tool for greater economic and political unity, the AMU has ironically served as a theatre for traditional rivalries to play out. Comprised of Algeria, Libya, Morocco, Mauritania and Tunisia, it has not held a meeting of its Head of States Council since 1994. Testament to such a stalemate, the communiqué following the first EU-Morocco Summit of March 2010 specifically mentioned the importance of regional integration, regretting the "difficulties (the AMU) is encountering."[89] Similar power politics is hindering the development of another major initiative: namely, the Agadir Agreement for the Establishment of a Free Trade Zone between the Arabic Mediterranean Nations (February 2004). To date, the border between Morocco and Algeria is still officially closed over the issue of the Western Sahara. In addition, Mauritania and Libya severed diplomatic relations following an alleged coup attempt in 2003.

b. Heavy consequences

This situation has clear consequences: intra-Maghreb trade is invariably low, especially in the field of energy. For instance, Algeria only exports 1Mtoe per year of petroleum products (or 4.6% of its oil exports) to its next-door neighbor, energy-hungry Morocco.[90] Algeria sells no more than 0.5Gm3 of natural gas per year (less than 1% of its total sales) to the Maghreb area.[91] Finally, 2% only (or 0.6 TWh) of its electricity generation goes to its immediate neighbors. Morocco's energy trade with Maghreb neighbors amounts to only 11% of its total, while Tunisia's barely reaches 14%.[92] *Appendices 11 and 12* provide an overview of oil and electricity flows between Maghreb countries.

c. Yet not a deal-breaker

Regional integration is not a major obstacle to the realization of trans-Mediterranean solar cooperation because initial rollouts could occur on a bilateral basis. This barrier would only become *dependent* at a much later stage in the process, namely for achieving a complete Mediterranean ring. At that point, cooperation among North African countries would obviously make solar trade more cost-effective and more reliable; a larger and fully integrated distribution network would indeed reach consumers more efficiently and feature contingency plans for potential disruptions.

Yet even at that point, it is unclear whether or not regional integration in the sense of deep economic and political cooperation would actually be vital. North African countries have effectively found ways to cooperate and deal with one another, both in the

past and presently. While some diplomatic channels are firmly closed, a fair amount of dealings actually occurs on "second-order" policy levels. The best examples of that are the various gas exports pipelines towards Europe (Algeria-Tunisia and Algeria-Morocco), on which "transit" countries are able to levy a share (for a non-negligible 3% of Algeria's total exports in 2006).[93] Occasional ministerial-level meetings — notably in the energy and transportation sectors — still occur among North African states and sometimes even within the AMU framework.

d. Cooperation, not reconciliation, is needed

Because a complete Mediterranean ring would require infrastructure investments to reinforce the existing North African cross-border networks (cf. *Appendix 13*), states would have to interact and work together. This, however, has proved not to be out of reach. Short of intra-Maghreb reconciliation, cooperation on solar energy could provide precisely the type of economic, developmental, and energy security incentives necessary for operational cooperation to occur within North Africa.

Barrier #10: Insufficient investment security

A common characterization of business opportunities in North Africa —whether right or wrong— typically emphasizes two main points: cheap labor and a "high-risk" environment. As such, the argument of "investment security" was quickly put forth as a potential obstacle to a large-scale rollout of solar energy in the region. Criticisms included the region's lack of transparency in business dealings, legislative "instability",[94] the state's active involvement in the economy, potential expropriations, and risks of terrorism.

Such views nevertheless omit the reality that Europe and North Africa are already engaged in a broad commercial relationship. The European Union indeed represents the single most important trading partner for the larger Southern Mediterranean area, with EU exports of approximately €132 billion in 2008 (i.e. 10% of total EU exports and 40% of the region's imports).[95] In turn, exports to the EU reached €116 billion (i.e. 7.5% of total EU imports and 44% of the region's exports).[96] Even more critically, European companies have been long-standing business partners in the region as in the case of Germany's Siemens (46 years in Algeria), France's Alstom (40 years in Morocco) or Italy's ENI (47 years in Tunisia). North African governments do recognize that European firms —particularly large ones— are a source of employment, growth, and investment.

In addition, North African countries have made substantial progress in the quality of their business environment. To be sure, more remains to be done but the situation is improving especially in comparison to select peers (cf. *Figure 12*):

***Figure 12*. Overview of recent global rankings**

	MOROCCO	ALGERIA	TUNISIA	MENA	OECD	EGYPT	TURKEY	ITALY	SPAIN
2009-2010 Political Instability Index (out of 165) ↑	98	61	134	98	136	106	55	121	104
2010 Ease of doing business (out of 183) ↓	128	136	69	92	30	106	73	78	62
Starting up a business	76	148	47	90	54	24	56	75	146
Dealing with construction permits	99	110	107	95	46	156	133	85	53
Employing workers	176	122	108	86	82	120	145	99	157
Getting credit	87	135	87	112	35	71	71	87	43
Protecting investors	165	73	73	93	66	73	57	57	93
Trading across borders	72	122	40	76	33	29	67	50	59
Enforcing contracts	108	123	77	115	32	148	27	156	52
2009 Corruption Perceptions Index (out of 180) ↓	89	111	65	71	22	111	61	63	32
2009-2010 Global Competitiveness Index (out of 133) ↓	73	83	40	44	23	70	61	48	33

Source: The Economist Intelligence Unit (2010), The World Bank (2010), Transparency International (2009), and World Economic Forum (2010).
Note: MENA and OECD figures reflect the authors' calculation when not provided; upward or downward arrow indicates directionality of the ranking; green and orange shading respectively denote areas of strengths and weaknesses.

Of all three countries, Morocco seems to be the EU's closest partner. In recognition of its "raft of reforms," the country was granted "advanced status" on October 13th 2008.[97] The two parties just held their first Summit on March 7, 2010, which highlighted Morocco's goal of further inclusion into the Trans-European Transport Networks. Morocco is currently positioning itself as a "reservoir of growth" for a post-crisis EU. The EU, in turn, represents a real "label" in terms of regulatory convergence and legislative frameworks.

Arguably, Tunisia is also "looking north" in light of the many social, economic and cultural ties that bind it with Europe (especially Italy and France). The country has embarked on a variety of reforms and it enjoys high levels of security and good quality education.[98] Large corporations are reportedly enjoying a very friendly business environment (i.e. "off-shore regime"), compared to smaller companies that might be competing with Tunisian players.

The real question mark remains Algeria, characterized by many as still a "closed" system into which foreign observers only have limited insight. In addition to market transparency and stability issues, the country went through a very bloody civil war in the early 1990s and has now become the base of terrorist organization "al-Qaeda in the Land of the Islamic Maghreb."[99] Having said that, the country's leadership is moving forward, looking to partner up with global powers like the U.S. or China. Long-standing industrial partnership and reinvigorated cooperation in gas trading arguably set a pretty strong precedent in terms of investment security for EU actors.

It is thus fair to say that common perceptions of "investment insecurity" about North Africa are largely overstated. While the region does have its share of problems, it is in fact much more stable than acknowledged (especially in recent years). Ultimately, common concerns over investment security are a reflection of the overall need —felt by industry especially—for "institutional backing" on behalf of governments, and the EC in particular. Private sector involvement will be fundamental to the realization of trans-Mediterranean trade in solar energy. It is therefore critical that the EC provides clear and informed support to the project in order to promote the kind of environment that will incentivize industry to compete. What industry needs, ultimately, is not financial support but institutional cover.

In order to make sure Barrier 10 does not turn into a *dependent* obstacle, the EC should:

REC

State the EC's institutional backing of the project, via a joint communication by Commissioner Hedegaard and Commissioner Oettinger, highlighting the relevance of trans-Mediterranean solar trade to Europe's central challenges of climate change and energy security.

Barrier #11: Energy dependence on North Africa

a. European energy dependence

The European Union is highly energy dependent, importing 82.6% of its oil, 60.3% of its gas, and 53.1% of its total fuels (a figure that could reach 70% by 2030).[100] It heavily relies on Russia for the supply of both its crude oil (34%) and gas (41%).[101] The EU's concentrated dependence on such an unstable region is the reason why energy security is a central challenge to the EU today. In light of the 2006 and 2008 crises between Ukraine and Russia, efforts have become more pronounced not only to broaden the mix of sources, but also to diversify suppliers, transport routes and transport mechanisms.

b. Between Scylla and Charybdis?

Trans-Mediterranean cooperation on solar energy arguably meets the conditions laid out to improve European energy security, however, critics contend that by choosing this path the EU would merely substitute one form of dependency for another; trading high reliance on unstable Russia for hazardous trade with unreliable North Africa. Instead they suggest the EU should look into alternative supply routes, potentially Eastern Europe and Turkey.

c. More than meets the eye

Several counterpoints can be made to the afore-mentioned assertion of "perilous dependence on North Africa". First, as argued in Section VII, Barrier no.10, North Africa has not proved to be as unstable or risky as is oftentimes perceived. Morocco, Algeria and Tunisia are "looking north" and have embarked on a path of promising reforms.

Second, the precedent in energy cooperation with a North African country arguably plays in favor of the region. Algeria is in the process of establishing a Strategic Energy Partnership with the EU, to whom it currently supplies 17% of consumed gas (its largest export market). The country does realize the prominence of Europe in its customer portfolio, as attested by the public position it took at the height of the 2006 Ukraine-Russia crisis.[102]

Third, the "new dependency" claim fails to appreciate the fact that North African power would at best come as a "subordinate" source of supply to European markets. The bulk of the production would still originate in Europe – whether through coal, nuclear, renewables, LNG, or alternative natural gas routes.[103] Even the most ambitious plan in the current policy landscape, namely DESERTEC, aims to provide "only" 15% of Europe's electricity needs by 2050 under a best-case scenario.

Fourth, North African suppliers would have close to zero incentive to blackmail European consumers. For one thing, compromising solar energy trade with the EU likely would have serious consequences on other bilateral trade flows. North Africa is heavily dependent on Europe for both its overall import and export markets.[104] It is very unlikely that any individual country would take on the EU as a bloc; very similarly to Russia who has always tended to take on relatively "weaker", peripheral countries.

Fifth, and most critically, there is virtually no incentive for solar energy producers to renege or default on their obligations. Contrary to oil or gas, electricity cannot be stored. An appropriate metaphor for power already integrated to a grid would be that it "gets pushed". While in the case of hydrocarbons – where exporting countries only postpone profits by delaying supply – electricity-exporting countries cannot store the withheld electricity and thus have to forgo profits. As such, the cost of withholding electricity exports as a means of applying political pressure ends up being much more expensive for the exporting country.

Finally, while investigating alternative energy routes such as Eastern Europe or Turkey has a lot of merit (and in fact should be done), a strong case can be made that these regions are also prone to much instability – if not more than North Africa today. Two ad-

ditional arguments specifically make Turkey an arguably riskier candidate: first, most of the transiting gas would potentially come from Iran; second, relying heavily on Turkey for energy supply could jeopardize or hinder the EU's latitude in other policy areas such as enlargement.

d. Whose dependency?

A closer look at the situation indicates that the "perilous dependence on North Africa" claim suffers several shortcomings: North Africa recently has proved to be a rather stable region; countries there have proved to be reliable trade partners; trans-Mediterranean solar energy would come as "secondary" supply; blackmailing European consumers would have serious bilateral consequences and come at a high price; and alternative routes are arguably as risky if not riskier. For all these reasons, dependency on North Africa does not constitute a barrier to the realization of trans-Mediterranean trade in solar energy.

VIII. POLICY RECOMMENDATIONS

REC

Progress on every one of the independent and dependent barriers is a necessary condition for the viability of the policy proposal. On every one of these barriers, sufficient progress must be made, yet none of these barriers will lower themselves automatically. As with all large and complex systems, energy systems are principally defined by inertia. The most central policy recommendation of this study is, therefore, that the EU should resolve to turn the proposal into an actionable policy option and embrace the fact that **resolute and immediate action** on all of the independent and dependent barriers is necessary to get us there.

1. Don't get distracted by overestimated barriers

REC

While urgency is high on the independent and the dependent barriers, no progress is necessary on the overestimated barriers in order to bring about the necessary conditions for a first step towards trans-Mediterranean trade in solar energy. It is therefore essential **not to get distracted by these overestimated barriers** and to try to prevent the proposal to be framed in reference to them rather than to the barriers that actually require serious work.

2. Continue to lower independent barriers with full force

REC

Decision-makers should charge ahead with full force on lowering the independent barriers. While **framing** the public debate, it is important to communicate clearly that the effort, cost, and friction that progress on lowering the independent barriers will entail are not singularly attributable to the proposal of trans-Mediterranean trade in solar energy but rather to European energy policy at large – even totally independent of the proposal.

a. High cost of renewable energy

REC

The European Union and its member states should **continue their ambitious R&D agenda** in the field of renewable energy.

REC

At the same time, the Commission should steer more funds to **expand R&D on technologies that are most applicable to North Africa**, such as CSP.

b. Ineffective electricity transmission within the EU

REC

Linking North Sea offshore grid capacity and the Baltic interconnection project will understandably be prioritized in the future "energy infrastructure" package. In that process, however, the EC should not miss the opportunity to **establish clear guidelines and possibly a blueprint for any future interconnection plans.** The EC should be mindful of its limited expertise on the matter and make sure to involve all relevant institutional stakeholders, industry players, national and regional authorities. Such issues of transmission planning and market frameworks provision ultimately pose the important question of an EU-wide Commissioner for Infrastructure.

REC

Upgrading the EU's networks will require massive investments. In the future, the EC should remain open to **alternative financing mechanisms** such as infrastructure bonds and growing European pension investments. Any pan-European infrastructure financing announcement is to be welcomed, but the EC should make sure going forward that it funds equally electricity and gas projects (i.e. gas received €400 million more on March 4th).

REC

Upgrading the EU's networks (especially "smart" grids) will warrant a major "cultural" revolution in the way consumers think of, and use, electricity. The EC should therefore prepare public opinion by launching a **EU-wide citizen consultation on energy supply flexibility**, stressing the importance of integrating renewables. The EU should frame the upgrade both in the language of sustainability and cost-savings.

REC

Since the challenge of reforming electricity market operations is so formidable, it is essential that the EC **entrusted both ENTSO-E and ACER with necessary authority**. The EC should also ensure that these two agencies do not end up competing against one another, and that integrating renewables capacity shows up high on their respective priorities list.

REC

While ACER is yet to start operating, it is critical that the EC invests in its success. A weak **ACER** would seriously hinder chances for EU-level reform. This means **strong backing from Brussels**, both in terms of institutional support of ACER's leadership and in the latitude granted to the organization as it issues "binding decisions" to MS under certain circumstances.

REC

ENTSO-E so far has proved to be a very proactive organization, positioning itself as a "feedback loop" between TSOs, investors and policymakers. Its recommendations, though non-binding, should be an integrant part of the upcoming infrastructure package consultations. Once the 10-year network development plan system has gone through several convincing iterations, the EC should consider **transferring power to ENTSO-E for electricity transmission policy**.

REC

In light of recent discussions in the Parliament, the EC should look favorably upon, and throw its full weight behind, the proposal requiring countries to **report on energy infrastructure investments**.

c. Insufficient market integration and policy harmonization at the EU-level

REC

In order to allow for the import of renewable energy across the Mediterranean, the EU and its Member States should **continue and accelerate the policy of integrating European electricity markets**. While doing so, the EU should takes steps to ensure that domestic efforts to roll out renewables in the Member States continue and are not supplanted by the trade in renewables. EC should investigate means with which trade in green electricity within integrated markets could be regulated so as to follow the **principle of additionality**.

REC

The EU should encourage the debate regarding the role and extent of renewable energy trade in the promotion of renewables within the EU. Once this question has been resolved sufficiently, the EU should **give more concrete guidance to Member States** about how they may make use of trade to maximize renewables by updating and clarifying articles 6, 7 & 8 of the Renewable Energy Directive.

REC

As to the willingness of the utilities to import, the European Commission should work with Member States to change the **incentive structures of utilities** until all of them stand to benefit from cross-border trade in electricity in order to overcome the resistance of utilities to the integration of electricity markets. All utilities should be incentivized to maximize the share of renewables in their mix, *both* from domestic sources and imports.

REC

Instead of enforcing harmonization,[105] the Commission should support the **voluntary cooperation and coordination between Member States in reforming their support schemes** and in making sure that all utilities are given the incentives that would make them interested in maximizing the share of renewables in their mix through imports of green electricity.

3. Engage dependent barriers sufficiently to turn the proposal into a viable policy option

Because all effort, cost, and friction caused by progress on lowering the dependent barriers risks turning into sunk cost in case the policy proposal is discarded in the future, these barriers should only be lowered by as much as is necessary for the policy option to become actionable. Therefore, the spirit of the policy recommendations in relation to the dependent barriers is to find the right balance between inaction and wasteful activism. On

each of the four dependent barriers, the European Commission should make a judgment as to how much progress must be made for the policy proposal to become viable, and on how this progress can be made at minimal cost.

a. Insufficient clarity regarding technology

REC

Because the open questions regarding technology are numerous and so fundamental that at least some progress towards their resolution must precede any large-scale deployment strategy, and because many of the open questions are inherently site-specific, an array of plants encompassing all sorts of technological variants must be constructed and studied on site in North Africa. As will be noted below, the same is true for all but one of the dependent barriers: progress on technological uncertainty, cost, and inadequate legal and commercial frameworks in North Africa all require initiating a **pilot phase of projects** that exposes North Africa to the experience of dealing with renewable energy.

Other leading players have come to the same conclusion: the World Bank's dedication of $750,000 to a $5.5 billion project of CSP plants in five MENA countries illustrates the Bank's interest in getting capacity installed on site.[106] The Mediterranean Solar Plan of the Union for the Mediterranean also calls for a "first set of projects to be launched in 2010-2011" under the "Action Plan".[107] However, these institutions only vaguely suggest the nature of such a pilot phase in North Africa and the Middle East. We will offer further details about the main components of such a pilot phase after we have deduced what it must achieve to lower each dependent barrier.

In order for the pilot phase to lower the barrier of technological uncertainty, the full breadth of promising technological variants of solar technology must be deployed. The projects must provide new insights regarding the open questions of storage, hybrid plants, cooling and water needs, and desalination potential. The European Union should also ensure that a productive cooperation between industry and research institutions develops around the sites, and that these partners come from Europe as well as North Africa. Furthermore, the EU should ensure that knowledge transfer between different actors during this pilot phase is maximized, for example by supporting regular conferences and data sharing between the stakeholders of the different projects.

b. Cost of renewable energy specifically in North Africa

REC

Similarly to the resolution of technological questions, sufficient clarity about the cost of renewables in North Africa can only be gained through experience with a number of plants of different technologies on site in North Africa. Between the main types of solar technologies, PV has less site-specific cost factors than CSP: the cost of PV is a more

simple function of solar irradiation, the conversion efficiency of the specific PV modules, and their manufacturing cost. Thus, while some experience with utility-scale PV must be gained in the region, the **pilot phase ought to focus on CSP**, which has more site-specific cost components and is much closer to competitive cost than PV, as we have seen.

REC

In an effort to **ameliorate the competitiveness of renewables in North Africa**, the EU should support North African states as they work on the competitive reorganization of their electricity markets and as they try to phase out or reduce the subsidies of natural gas and electricity tariffs.

c. Lack of substantial trans-Mediterranean transmission

REC

Submarine trans-Mediterranean electrical transmission is expensive. Only a large-scale rollout of generating capacity in North Africa would warrant its construction. This is not the case yet. As such, the EC should presently stick to its position of "**signaling" to stakeholders** that it has taken note of future needs for interconnection (cf. latest Green Paper). The point is to sustain the level of commercial and political interest through what remains a long-term horizon.

REC

In order to prepare the eventual construction of trans-Mediterranean electrical transmissions (if warranted), the EC should urge **ENTSO-E to create a North-Africa "Prospection Group"** tasked with coordinating feasibility studies and technical analysis. The mandate of such a group would be to centralize expertise and provide clear and informed EU-wide guidance to all stakeholders.

REC

Completing the Tunisia-Italy electrical connection arguably is the next big step towards achieving the long-term objective of a full Mediterranean grid. Having announced the funding of a submarine cable between Sicily and continental Italy on March 4, 2010 (€110 million), the EC should now see to the **effective implementation of the remaining portion of the connection (namely Tunisia-Sicily)** as currently foreseen under Project El-Med.

d. Inadequate legal and commercial frameworks in North Africa

REC

The pilot phase of solar energy plants is very important for the lowering of the commercial and legal barriers as well. As we noted when defining the barrier, private sector investors will only deem the rollout of many plants bankable once the legal and commercial framework in North Africa has been tested and defended in courts. Thus, it is essential that the pilot phase bring **experience and stress tests to the local legal and regulatory systems** of North Africa, so that the legal and commercial framework can emerge strong enough to carry large-scale deployment.

REC

The European Union is already notably involved in **advising North African governments** about legal and commercial frameworks for renewable energy and it should continue to do so. It should give advice through the mechanisms of the neighborhood policy, strengthen domestic institutions such as the RCREEE (Regional Center for Renewable Energy and Energy Efficiency) in Cairo, and foster cooperation of regulators and other stakeholders through mechanisms such as Med-REG, Med-EMIP, IMME, etc.

REC

Following the signing of **memoranda of understanding regarding energy** policy cooperation with Morocco (2007) and Egypt (2008), the EU should pursue to conclude the talks about similar MoU's with partner countries in the region.

REC

The Commission's newly announced project "Paving the way for the Mediterranean Solar Plan", approved in November 2009, is a step in the right direction, but it is small money for an excessively large purpose: the project wants to cover all technologies, engage rural decentralized and utility-scale electricity generation, energy efficiency, R&D, transmission integration, and more. To avoid this worthwhile endeavor from becoming irrelevant, the Commission should make sure that the project has the means that it needs, to excel in a mission that ought to be more clearly defined.

REC

In the case of European efforts to build a common energy network, the Commission already considered that "in exceptional cases, such as large-scale regional projects or projects involving a third country, a **European coordinator** may be appointed."[108] This kind of a position could really unite the EU's many efforts and initiatives, and thereby increase coherence and usefulness to the countries of North Africa.

REC

In the meantime, the EU should **clarify articles 9 & 10 of the Renewables Directive**, making it clearer to governments within and outside of the EU on how joint projects can be planned, financed and executed. Our research in North Africa clearly indicated that North African governments were at a loss as to the exact meaning of these articles, and about how to proceed in testing whether mutually beneficial joint projects with EU neighbors were possible.

4. Enable a pilot phase

As pointed out above, three of the four dependent barriers can only be lowered if a substantial number of solar energy plants are constructed, tested, and studied on site in North Africa. The key characteristics that the pilot phase must have in order to lower these barriers are summarized in the table below:

To lower the barrier of:	The pilot phase must:
Technologic uncertainty	include all promising technological variants
	test storage, hybrid plants, cooling and water needs, desalination
	foster cooperation between industry and research institutions
	maximize knowledge transfer between different actors
Cost	include PV but focus on CSP
	bring unique insights on site-specific cost components
Legal and commercial framework	test local regulators
	test local legal and judicial systems
	lead to a domestic commercial framework

Source: Authors.

a. Organizational structure

Exactly **how such a pilot phase should be configured**, and what role the European Union should play in this regard, are questions that must be discussed within the EU and with other stakeholders. Possible organizational structures could range between two extremes:

- *Very uncoordinated*
  A number of individual projects in numerous countries receiving financial and other backing from the EU and many other actors without any coordination;

- *Highly institutionalized*
  A monolithic structure of coordinated projects where a lead organization like the World Bank or the ADB works with national governments and donors in planning and overseeing the deployment of pilot projects.

b. Where should the generated electricity go?

Many proponents of a pilot phase argue that the electricity should be transmitted to Europe from its very inception. This concept proposes to finance the pilot phase through a purchasing power agreement or a Europe-wide feed-in tariff for green electricity from North Africa. It calls for EU member states to organize financial contributions and the electricity transmission within Europe.

REC

This study strongly discourages such an approach. We recommend that the **electricity to be generated by the plants of the pilot phase should remain in North Africa** to be consumed domestically, for several reasons. Firstly, legal and commercial frameworks in North Africa will only improve if they are exposed to the full value chain of green electricity – regulators, legislators, and the judiciary should have to manage everything from construction permits to intermittence management and payments to IPPs. The pilot phase would help North Africa meets its growing electricity demand from the start, thus allowing North Africans to develop ownership of the concept. As such, the pilot phase would be much less prone to security threats or to political hijacking by anti-Western opinion-makers if the electricity stayed local. Most importantly, keeping the electricity in North Africa avoids the pitfalls that could derail or at least delay the pilot phase such as unforeseen interruptions of transmission construction projects due to local political pressure or other reasons. The pilot phase needs to get off the ground as soon as possible. Plants can be built within two to three years. Trans-Mediterranean transmission would likely take much longer and would thus threaten to delay the pilot project substantially.

In short, by keeping the electricity in North Africa, the pilot phase achieves full learning effects and full ownership by North Africa, without having to build trans-Mediterranean transmission system and organizing the electricity absorption and financial burden-sharing within Europe.

c. Financing the pilot phase

Naturally, the central question regarding a pilot phase is its financing, and this challenge becomes even more difficult when the electricity remains in North Africa, where the cost differential between the generating cost of each plant and the domestic electricity tariff is even higher than in Europe. However, we must keep in mind that the pilot phase does not require an enormous amount of capacity to be built. Therefore, the absolute figure to be covered will remain manageable. Furthermore, since fixed costs would take up the bulk of the cost and O&M costs are negligible, financing the pilot phase comes down to covering the installation costs.

The World Bank noted that it expects to be able to use the $750 million it set aside as part of the Clean Technology Fund for CSP plants in the MENA region to attract another $ 4.75 billion in co-financing. This would be formidable bedrock for the financing of a pilot phase. Other partners include European export credit agencies, the African Development Bank, the European Bank for Reconstruction and Development, other development banks, and the European Investment Bank (EIB).

REC

The European Commission should **take a proactive role** in embracing the policy of working with partners such as the World Bank and the national governments of the MENA region to enable a pilot phase in the region. The EU should engage all levers at its disposal to guarantee that adequate financing for a sufficiently ambitious pilot phase is found so that the learning effects of the pilot phase truly materialize.

REC

The **EIB should take a leading role** in financing the pilot phase. Since the Lisbon treaty, the EIB is allowed to go beyond disbursing loans by taking on equity positions. This might prove a very innovative and effective contribution. In the words of German minister for the economy, Rainer Brüderle: "This is the kind of large-scale infrastructure project that the European Investment Bank was created for."[109]

REC

The EU itself **could direct certain funds** to the pilot phase; for instance through the Neighborhood Policy or the annual €2.4 billion of Copenhagen Accord "fast start" financial assistance for developing countries.[110] Another contribution could come from loan guarantees issued by European national governments, as has been suggested by the German government.[111]

REC

The most creative and potentially powerful way to finance part of the pilot phase lies in **virtual trading**. In a nutshell, the idea is that the electricity remains in North Africa, but its "greenness" gets sold to Europe and the profits of this transaction help to cover the cost differential. Virtual carbon trading is no silver bullet but can nonetheless make a substantial contribution to the financing of a pilot phase, and the EU is a key player, as it represents the largest virtual trading market worldwide. The EC should use this leadership position and seriously consider what creative mechanisms could be established to help finance the pilot phase. Please see *Appendix 14* for details on the different kinds of applicable virtual trading schemes.

REC

While virtual trading might prove an effective part of a financing strategy, it faces opposition. Some critics claim that virtual trading should be kept to a minimum or even eliminated because it offers an easy way out for countries that fail to develop their own renewables potential, or to reach their carbon emission reduction target. We believe that this skepticism could be overcome by two provisions, however. Firstly, the EU and

its Member States could agree to **limit virtual trading to the pilot phase** and not to automatically extend it to any deployment after that. Secondly, the EU and its Member States could agree to combine virtual trading with a principle of additionality, under which all carbon reductions or renewable energy certificates that originate from the pilot phase and get sold to Europe do not replace European obligations, but automatically get added onto the overall targets of the EU or the member states, in order to guarantee that no displacement of local efforts takes place.

APPENDICES

Appendix 1. List of interviews conducted

European Commission

Giulia BUSCOSI, Chargée de programmes – Sustainable development and Environment
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Cyril DEWALEYNE, Chargé de programmes – Energy and Governance
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Peter VIS, Head of cabinet
Commissioner for Climate Action

European Investment Bank

David GONZALEZ-GARCIA, Energy engineer

Philippe MAYSTADT, President

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Kamal EL MAHDAOUI, Chef du service Coopération Régionale Euro-Méditerranéenne
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Tunisian labor unions

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Government of Germany

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Ralf CHRISTMANN, Research and Development in the field of Renewable Energies
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Michael FERNAU, Ministre conseiller
German Embassy, Tunis

Claudius FISCHBACH, Minister Counselor – Policy Planning Staff
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Karina HÄUSLMEIER, EU Energy Policy
Federal Foreign Office

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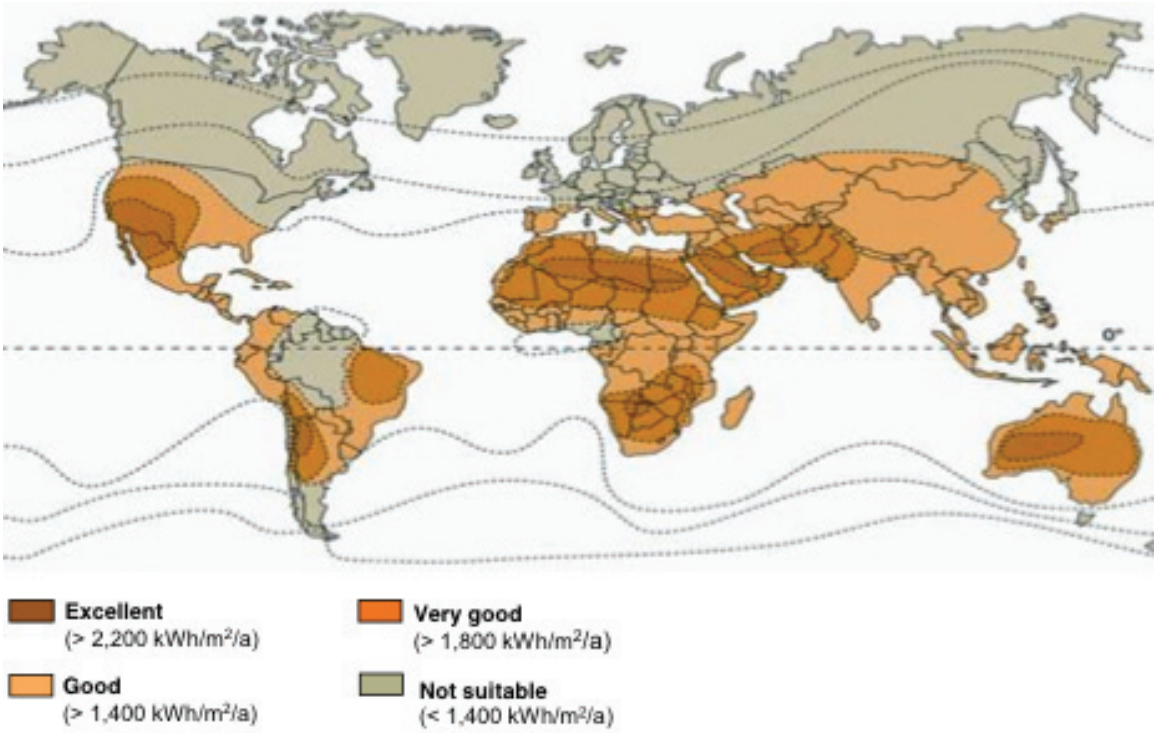
European Solar Thermal Electricity Association

Thierry POMMIER, Deputy director
European Solar Thermal Electricity Association

Jan RODIG
DESERTEC Industrial Initiative

Appendix 2. Global solar irradiance and potential for large-scale solar power generation



Sources: Solar Millennium, ISET, DWD, BMU, SolarAccess, and BUND Naturschutz.

Appendix 3. Population growth projections in North Africa

Country	1971	1980	1990	2000	2002	2004	2006	2010p	2020p
Algeria	14.2	18.8	25.3	30.5	31.4	32.4	33.3	35.2	39.9
Libya	2.1	3.0	4.3	5.3	5.5	5.7	6.0	6.7	8.2
Mauritania	1.3	1.6	2.0	2.6	2.8	3.0	3.1	3.6	4.5
Morocco	15.4	19.3	23.9	27.8	28.5	29.1	30.5	32.3	36.8
Tunisia	5.2	6.4	8.2	9.6	9.8	9.9	10.1	10.7	12.1
Total	38.1	49.1	63.7	75.8	78.0	80.1	83.0	88.5	101.5

Source: Faïd (2008); World Bank, World Development Indicators 2007; UNCTAD, Trade and Development Report, 2007.

Appendix 4. GNP growth projections in North Africa

Country	1970	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007e	2008p	2010p	2020p
Algeria	4.9	42.3	62.0	54.8	56.2	58.9	62.9	66.2	69.6	70.8	73.0	76.6	87.7	127.7
Libya	4.0	35.5	28.9	34.5	36.0	37.2	40.6	42.7	45.3	47.7	50.9	55.4	53.3	67.3
Mauritania	0.2	0.7	1.0	1.1	1.1	1.1	1.2	1.2	1.3	1.4	1.5	1.5	1.6	2.1
Morocco	4.0	21.0	28.9	37.1	39.4	40.7	42.9	45.1	46.2	49.9	51.0	54.1	59.5	80.6
Tunisia	1.4	8.7	12.3	19.4	20.4	20.7	21.9	23.2	24.1	25.5	27.1	28.6	30.9	45.9
Total	14.0	108.0	133.0	147.0	153.0	159.0	170.0	178.0	187.0	195.0	204.0	216.0	233.0	323.6

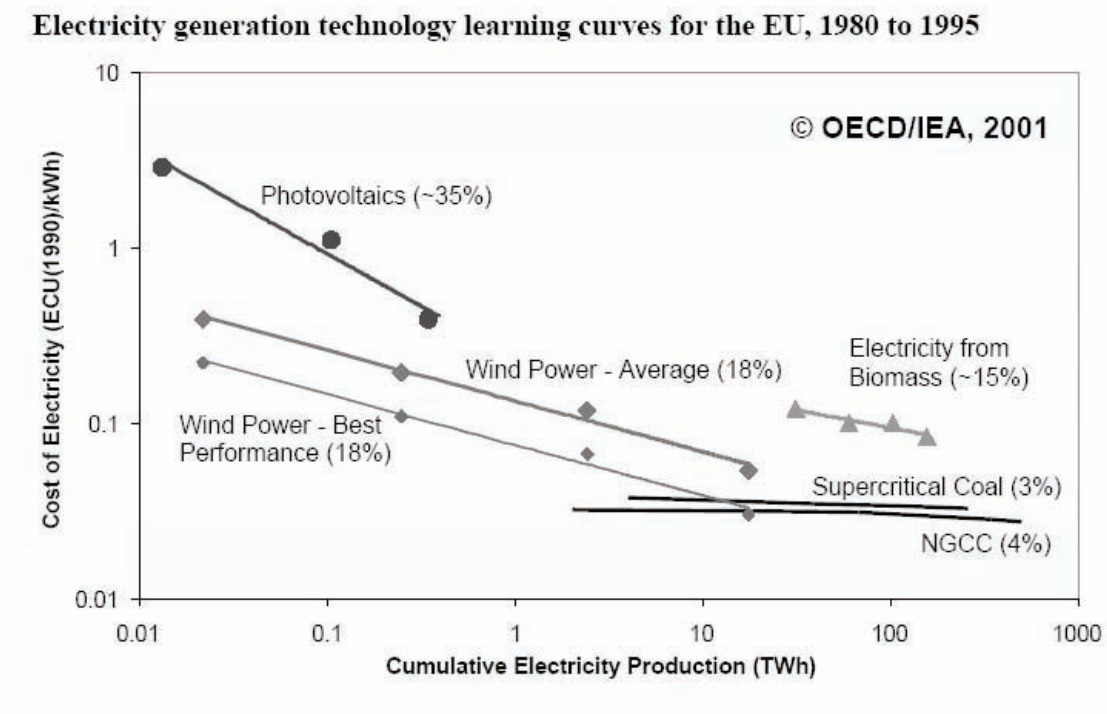
Source: Faïd (2008); World Bank, World Development Indicators 2007.

Appendix 5. Status quo in main sources of primary energy for Morocco, Tunisia and Algeria

Main sources	**Crude oil**			**Petroleum products**			**Gas**				**Total Primary Energy**			
2007 (Mtoe)	*Pro*	*Im.*	*Ex.*	*Im.*	*Ex.*	*Co.*	*Pro*	*Im.*	*Ex.*	*Co.*	*Pro*	*Im.*	*Ex.*	*Co.*
Morocco	0	6	-	5	(1)	8	0	1	-	0	1	15	(1)	10
Tunisia	5	1	(4)	3	(1)	3	2	2	-	1	8	6	(5)	6
Algeria	91	0	(59)	1	(19)	12	74	-	(51)	9	164	2	(129)	23

Source: International Energy Agency, http://iea.org/stats (2009).
Note: Table represents production (Pro), imports (Im.), exports (Ex.) and consumption (Co.). Total primary energy figures reflect statistical changes, as well as additional sources such as coal and peat, nuclear, hydro, geothermal, combustible renewables and waste, electricity and heat sources.
(1) In 2007, Morocco imported 3.3 Mtoe of coal and peat, used 2.8 for electricity plants and consumed 0.2.
(2) In 2007, Algeria imported 0.9 Mtoe of coal and peat, transformed 0.5, consumed 0.2 and lost 0.1 (dist.).

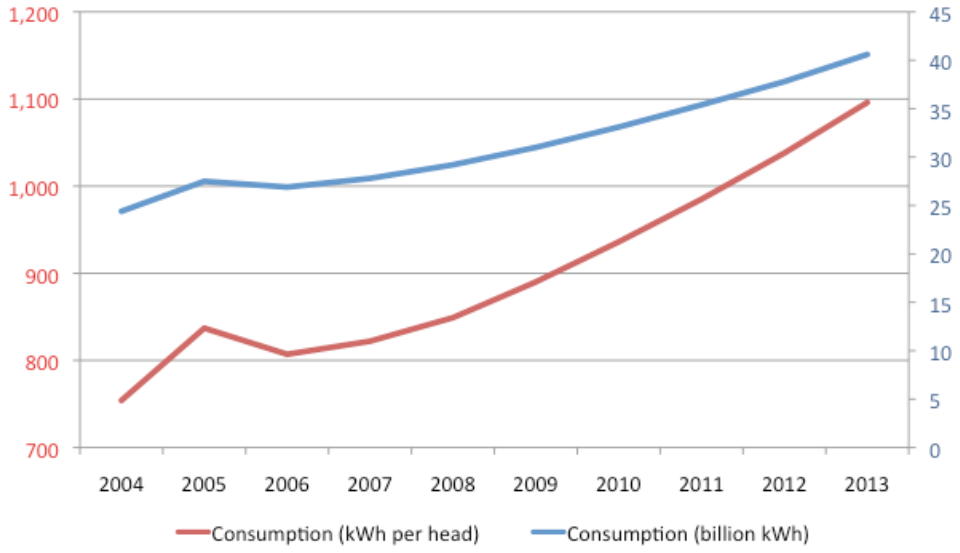
Appendix 6. Learning curves



Appendix 7. Map of Mediterranean gas pipelines

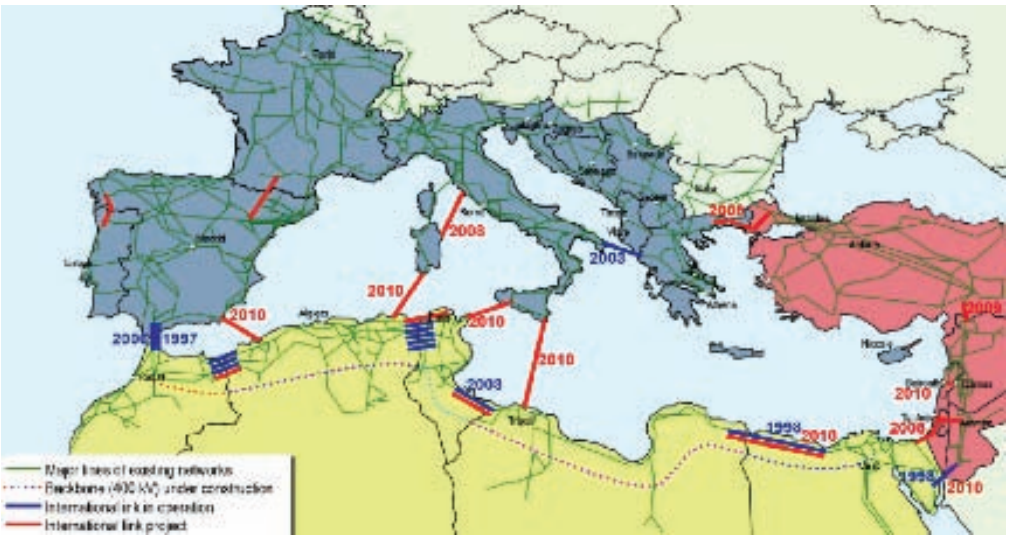
Sources: Sémhur (2009).

Appendix 8. Electricity demand projections in Algeria



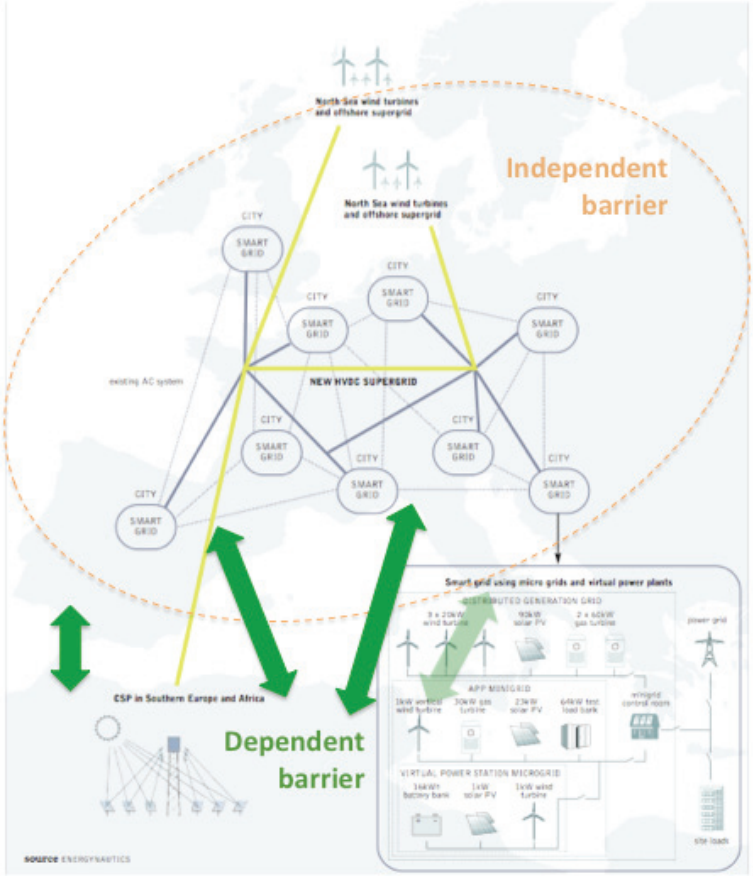
Source: The Economist Intelligence Unit (2009).

Appendix 9. Existing and potential trans-Mediterranean electrical connections



Source: OME in NPI, "Identification Mission for the Mediterranean Solar Plan: Final Report" (2010).

Appendix 10. Interdependent barriers



Source: Adapted from Energynautics; in Greenpeace International and EREC (2009), p. 9.

Appendix 11. Oil flows between Maghreb countries (Ktoe, 2005)

	Exporter							
Importer	**Algeria**	**Libya**	**Morocco**	**Tunisia**	**Total Maghreb**	**Rest of the Mediterranean**	**Rest of the world**	**Total**
Algeria		0	0	0	0	402	450	852
Libya	0		0	0	0	0	29	29
Morocco	975	37		0	1,012	490	6,167	7,669
Mauritania	0	0	0	0	0	0	0	0
Tunisia	0	779	12		791	191	3,278	4,260
Total Maghreb	975	816	12	0	1,803	n.a.	n.a.	n.a.
Rest of the Mediterranean	20,159	45,372	0	1,317	66,848		n.a.	n.a.
Rest of the world	140	779	0	0	919	n.a.		n.a.
Total	21,274	46,967	12	1,317	69,569	n.a.	n.a.	

Source: International Energy Agency and BP Statistical Review of World Energy (2005); in Faid (2009).

Appendix 12. Electricity flows between Maghreb countries (GWh, 2006)

	Exporter						
Importer	**Algeria**	**Libya**	**Morocco**	**Tunisia**	**Egypt**	**Spain**	**Total**
Algeria		n.a.	136	135	n.a.	n.a.	271
Libya	n.a.		n.a.	n.a.	123	n.a.	123
Morocco	159	n.a.		n.a.	n.a.	1,899	2,058
Tunisia	141	n.a.	n.a.		n.a.	n.a.	141
Egypt	n.a.	91	n.a.	n.a.		n.a.	91
Spain	n.a.	n.a.	27	n.a.	n.a.		27
Total	300	91	163	135	123	1,899	2,710

Source: Comité Maghrébin de l'Electricité; Observatoire Méditerranéen de l'Energie; in Faid (2009).

Appendix 13. Electricity interconnections between Maghreb countries (2006)

Interconnection	Voltage (kilovolts)	Year of commissioning
Ghazaouet, Algeria ↔ Oujda, Morocco	225	1988
Tlemcen, Algeria ↔ Oujda, Morocco	225	1988
Djebel Onk, Algeria ↔ Metlaoui, Tunisia	150	1984
El Aouinet, Algeria ↔ Tajerouine, Tunisia	225	1984
El Aouinet, Algeria ↔ Tajerouine, Tunisia	90	1952
El Kala, Algeria ↔ Fernana, Tunisia	90	1956
Mellousa, Morocco ↔ Tarifa, Spain	400	1996/2006
Medenine, Tunisia ↔ Abukamash, Libya	220	2003
Tobruk, Libya ↔ Saloum, Egypt	220	1998

Source: Comité Maghrébin de l'Electricité; in Faid (2009).

Appendix 14. Applicable virtual trading schemes to co-finance a pilot phase

There are two currencies in which this "greenness" could get sold: owners of a renewable energy plant in North Africa could get their plant certified as a project under the UN's Clean Development Mechanism (CDM), which entitles them to a set amount of certified emission reductions (CERs). These can be sold to governments, who buy them to avoid overshooting their emissions obligations under the Kyoto Protocol, or to European companies, who apply them to their emission allowance. Even thought the Kyoto Protocol is expiring in 2012, most industry analysts expect that all or many Kyoto signatories will find a multilateral way of keeping the CDM even without a Kyoto successor treaty.

Alternatively, owners of renewable energy plants could sell Renewable Energy Certificates (RECs), which means that they would keep the electricity, but sell the "renewable"attribute. The buyer of the RECs can now claim to have purchased renewable energy. Companies in 15 European countries and the United States buy RECs to fulfill renewable portfolio standards or simply to be able to claim to have purchased renewable energy.

It is difficult to predict what kind of sum could be generated from virtual trading. Assuming a carbon price of around € 10 per ton, owners of renewable energy plants in North Africa could earn about 1c/kWh of electricity by selling their CERs on the European Emissions Trading Scheme. Assuming that they have to cover a deficit of around 10c/kWh, virtual trading is no silver bullet but can nonetheless make a substantial contribution.

One problem with income from virtual trading is that it does not guarantee cash flows because the carbon price and the demand for RECs fluctuate. If the European Union or its Members States were to embrace virtual trading to finance a pilot phase, they should therefore consider the development of smoothing mechanism for price and quantity demanded, for example by buying a guaranteed sum of certificates for a set price and then auctioning them off later amongst member states and their companies.

List Of Acronyms

ACER	Agency for Cooperation of Energy Regulators
ADB	African Development Bank
AFD	Agence Française de Développement
CCS	Carbon Capture Storage
CDM	Clean Development Mechanism
CSP	Concentrating Solar Power
DG	Directorate-General
DG TREN	Directorate-General for Transport and Energy
DII	DESERTEC Industrial Initiative
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EIB	European Investment Bank
ENP	European Neighborhood Policy
ENTSO-E	European Network of Transmission System Operators for Electricity
ETS	Emissions Trading System
EU	European Union
GHG	Greenhouse Gas Emissions
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IPPs	Independent Power Providers
KfW	Kreditanstalt für Wiederaufbau
MED-EMIP	Euro-Mediterranean Energy Market Integration Project
MEDREG	Euro-Mediterranean Regulators for Electricity and Gas
MED-ENEC	Euro-Mediterranean Energy Efficiency in the Construction Sector
MENA	Middle East and North Africa
MS	Member States (of the European Union)
MSP	Mediterranean Solar Plan
Mtoe	Million Tons of Oil Equivalent
NEAL	New Energy Algeria
NIF	Neighbourhood Investment Facility
O&M	Operations & Management
OME	Observatoire Méditerranéen de l'Energie
R&D	Research and development
RCEEE	Regional Centre of Excellence for Renewable Energy and Energy Efficiency
TEN-E	Trans-European Energy Network
TREC	Trans-Mediterranean Renewable Energy Cooperation
TWh	Terawatt hours
TYNDP	Ten-Year Network Development Plan
UfM	Union for the Mediterranean
WTO	World Trade Organization

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World Economic Forum, *The Global Competitiveness Report 2009-2010*, 2010

Endnotes

1 The International Energy Agency estimates that world primary energy demand will grow by 40% from 2007 to 2030, with non-OECD countries accounting for 90% of the increase. By 2030 fossil fuels will remain at the center of energy sourcing, representing 77% of the demand increase. Demand for coal and natural gas are expected to grow respectively by 53% and 42%. Source: The International Energy Agency, *World Energy Outlook 2009 Fact Sheet*, 2009.

2 European Commission, *Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy*, 2006. According to the same study, EU gas imports could increase to 80% by 2030.

3 European Commission (DG TREN), *Statistical Pocketbook 2010 – EU Energy in Figures*, 2.2.3, p. 13.

4 Ibid, p. 14.

5 European Commission (DG TREN), *Statistical Pocketbook 2010 – EU Energy in Figures*, 2.2.2, pp. 10-11.

6 European Commission, http://ec.europa.eu/eu2020/, accessed March 16, 2010.

7 On January 28, 2010, the European Union formalized its support for the Copenhagen Accord on climate change and restated its conditional offer to increase its GHG emissions reduction target to 30% were other developed countries to agree to "comparable goals" and developing countries to contribute "adequately according to their responsibilities and respective capabilities". Source: European Commission, IP/10/97, http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/97 accessed March 16, 2010.

8 Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), *Concentrating Solar Power for the Mediterranean Region*, Study commissioned by Germany's Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, April 2005.

9 Southern European countries enjoy much lower levels of normal direct irradiance (with the exception of Spain) than North Africa (see Trieb et al., DLR, September 2009, for a comprehensive study of global CSP potential). The *2009 CSP Global Outlook* report points to consequent higher levelized cost of electricity in France, Portugal, and Italy. EU countries are also confronted with distinct constraints such as limited land availability or issues of "siting" and their political ramifications.

10 Though transmission costs remain substantial, the three broad components of land and subsea transmission (namely AC lines, DC lines, and converter stations) have seen their price decrease and their operational reliability increase. For more details on cost and loss-per-1,000 km figures, see K. Ummel and D. Wheeler, December 2008.

11 According to the international network of scientists and engineers "TREC", solar such a distance would allow for solar electricity supply. <http://www.trec-uk.org.uk/press/debate_2008-02-28.html>, accessed March 16, 2010.

12 Research programs have continued to flourish. Among others, Italian energy company Eni and MIT announced on January 15, 2008 a 5-year, $50 million cooperation (the Solar Frontiers Research Program) around advanced solar technologies, including novel PV materials and solar power plants design. Source: <http://web.mit.edu/newsoffice/2008/mitei-eni-0115.html>, accessed March 16, 2010.

13 See Robert O. Keohane and David G. Victor. *The Regime Complex for Climate Change* Discussion Paper 2010-33, Cambridge, Mass.: Harvard Project on International Climate Agreements, January 2010.

14 Strictly speaking, the UfM is a re-launch of the Euro-Mediterranean Partnership (formerly known as the Barcelona Process). Along with 27 EU countries, 16 partners from the Southern-Med and the Middle East belong to the organization. The UfM aims to "infuse a new vitality into the Partnership and to raise the political level of the strategic relationship between the EU and its southern neighbors." Source: European Commission, <http://ec.europa.eu/external_relations/euromed/index_en.htm>, accessed March 19, 2010.

15 The project was initially subject to a major disagreement between France and Germany (along with other EU northern states) over its overall pertinence as a separate institution and its statutory membership. A few months after its first official Summit in July 2008, the organization lost momentum and severely stalled in light of the winter 2008-2009 conflict in Gaza.

16 For instance, the Financial Times reported in July 2009 that DESERTEC had "won the support" of EC President Barroso. <http://www.ft.com/cms/s/2/759b35a6-6f00-11de-9109-00144feabdc0.html?nclick_check=1>, accessed March 17 2010.

17 Source: International Monetary Fund, World Economic Outlook <http://imf.org/external/data.htm>, accessed March 20, 2010. Figures expressed in international US$.

18 For a discussion of the implications on economic development of the mix of goods that a country produces, see R. Hausmann, J. Hwang, D. Rodrik, 2007. *What you export matters*, Journal of Economic Growth, Springer, vol. 12(1), pp. 1-25.

19 ESTELA, *Solar Power from Europe's Sun Bel*t brochure, 2009.

20 ESTELA, *The Solar Thermal Electricity Industry's Proposal for the Mediterranean Solar Plan*, 2009, p. 7.

21 DESERTEC Foundation, *Red Paper: An Overview of the DESERTEC Concept*, 2009, p. 6.

22 M. Faïd, "The Maghreb Energy Sector: Situation and Perspectives" (2008) and World Bank, World Development Indicators 2008.

23 Ibid, pp. 112-118.

24 Ibid, pp. 118.

25 The launch of the Moroccan and Tunisian solar plans constituted major public relations events, including strong local and international coverage and attempts at high-level diplomacy. For instance, observers noted the presence of U.S. Secretary of State Hillary Clinton at the Ouarzazate ceremony on November 3, 2009.

26 In his message to the March 7, 2010 Morocco-EU Summit in Granada, Mohammed VI reiterated his support for the UfM and the MSP and even explicitly mentioned DESERTEC. President Ben Ali included solar energy in his 2009 re-election campaign program and had endorsed "the German initiative concerning the adoption of a Mediterranean Project for Solar Energy". Sources: Agence Maghreb Arabe Presse, <http://www.map.ma/eng/sections/speeches/hm_the_king_sends_me4193/view> and The Seoul Times, <http://theseoultimes.com/ST/?url=/ST/db/read.php?idx=6900>, both accessed March 19, 2010.

27 As pointed out in Table 1, Morocco is much more dependent on energy imports (14 Mtoe) than Tunisia (1 Mtoe). Furthermore, Morocco is 97% electricity dependent with about 15% of its imports coming from Spain.

28 Out of a €2 billion estimated cost, Tunisia is looking to mobilize €1.4 billion from private investors and €20 million from international donors. While Morocco is yet to provide comparable information, similar public-private proportions and a heavy reliance on external capital mobilization are expected as well.

29 SolarPACES, Greenpeace International, and ESTELA, *CSP Global Outlook 2009*, p. 44.

30 In 2008, Algeria was the world's 14th largest oil producer (2 million barrels/day, of which 1.4 million was crude oil), 6th largest producer of natural gas (87 billion m^3), and 4th largest exporter of LNG (22 billion m^3). Source: The Economist Intelligence Unit, September 29, 2009.

31 Source: The Economist Intelligence Unit, December 7, 2009.

32 Source: Journal Officiel No. 19, Décret Exécutif 04-92; Ministère de l'Energie et des Mines, *<www.memalgeria.org/francais/index.php?page=237>,* accessed March 19, 2010.

33 NEAL was created under the auspices of the U.S. Department of Energy and with assistance from Oak Ridge National Laboratory. Source: Oak Ridge National Laboratory, <http://www.ornl.gov/sci/eere/international/neal_index.htm>, accessed March 19, 2010.

34 Annual growth in electricity consumption over the next five years, mostly driven by the government's ambitious housing program, infrastructure upgrade, and increased reliance on desalination for water supplies and industrial investment (The Economist Intelligence Unit, September 29, 2009).

35 Algeria's minister of energy and mines, Chakib Khelil, reportedly told local media that DESERTEC plans "were not concrete" and that his country would only participate "on (its) conditions". Source: The Economist Intelligence Unit, December 7, 2009.

36 The fund's resources shall come from oil taxes and be determined by the upcoming 2010 finance law. Source: Les Afriques, No. 8, September 2009, p. 16.

37 Source: Les Afriques, No. 89, September 2009, p. 16.

38 European Commission, *Statistical pocketbook 2010, Part 2: Energy,* p. 12.

39 European Commission, *Investing in the Development of Low Carbon Technologies (SET-Plan)*, R&D Investments in the priority technologies of the European Strategic Energy Technology Plan, SEC 2009, 1296, p. iv.

40 Ibid, p. 10.

41 European Commission, *Investing in the Development of Low Carbon Technologies (SET-Plan)*, R&D Investments in the priority technologies of the European Strategic Energy Technology Plan, SEC(2009) 1296, p. 47.

42 European Commission, *Towards a Secure, Sustainable and Competitive European Energy Network,* November 2008, p. 13.

43 Greenpeace International and EREC, "[r]enewables 24/7: Infrastructure Needed to Save the Climate" (November 2009), p. 3.

44 For instance, wind power supplied more than half of Spain's electricity demand for an entire night on November 7, 2009 (with peaks at 53%), setting a record of 11,546MW of simultaneous wind power generation. Source: Greenpeace International and EREC, "[r] enewables 24/7: Infrastructure Needed to Save the Climate", November 2009, p. 3.

45 For a recent in-depth analysis of necessary grid changes, see Greenpeace International and EREC, "[r]enewables 24/7: Infrastructure Needed to Save the Climate", since November 2009.

46 Ibid, p. 5.

47 Energynautics, a leading research company in the field of grid integration, ran a study comparing 30 years of weather data with European annual demand curves on a 15-minute basis. It concluded that there was only a 0.4% chance (or 12 hours a year) that high demand would correlate with low solar or wind generation, making the case for renewables' viability even stronger. Source: Greenpeace International and EREC (2009).

48 European Commission, *Towards a Secure, Sustainable and Competitive European Energy Network,* November 2008, p. 13.

49 Ibid, p. 3.

50 EurActiv.com, <http://www.euractiv.com/en/energy/eu-countries-report-about-energy-investment-plans-news-299431>, accessed March 21, 2010.

51 Member States have a track record of not informing the EC about their projects, as in the case of the Gazprom-ENI South Stream gas pipeline crossing six EU countries.

52 Source: EurActiv.com, <http://www.euractiv.com/en/energy-efficiency/EU-plans-grid-upgrade-renewables>, accessed March 21, 2010.

53 Source: ERGEG, "An ERGEG Public Consultation Paper" (December 2009), and ENTSO-E response (March 2010).

54 Source: European Commission, <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/231&format=HTML&aged=0&language=EN&guiLanguage=en>, accessed March 16, 2010.

55 European Commission: *Europe 2020 - A strategy for smart, sustainable and inclusive growth,* COM(2010) 2020, p. 13

56 Integrating electricity markets often implies reforms such as the breaking up of vertically integrated companies. That is not the issue here, however. We are only concerned with the point that utilities anywhere in Europe should be able to import green electricity from any region in Europe – or from North Africa for that matter.

57 European Commission Staff Working Document: *The support of electricity from renewable energy sources*. Accompanying document to the Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the promotion of the use of energy from renewable sources COM(2008) 19, p. 4

58 Article 6 allows for "statistical transfers": a Member State that generates more green electricity than is needed according to the national target may allow that extra capacity to be counted towards the target of another Member State, accepting remuneration in return. This effectively amounts to virtual trade of green electricity between Member States. However, article 6 remains vague and does not guide Member States in the process of arranging these deals. Secondly, article 7 and 8 allow Member States to join forces in financing a renewable energy project in any given Member State. While the electricity itself stays in the country of origin, all parties of the project may count a share of the total generating capacity towards their respective renewable energy targets. Lastly, articles 9 and 10 allow Member States to finance renewable energy projects in third countries outside the EU. However, the generated electricity can only be counted towards the targets of the EU Member State if it is actually transmitted into the EU and consumed there. It remains to be seen how Member States will make use of these mechanisms.

59 Greenpeace International, SolarPACES, ESTELA, *Concentrating Solar Power – Global Outlook 2009*, p. 83

60 Ibid, p. 83

61 Greenpeace International, SolarPACES, ESTELA: *Concentrating Solar Power – Global Outlook 2009*, p. 33.

62 For example, Kevin Ummel and David Wheeler: *Desert Power: The Economics of Solar Thermal Electricity for Europe, North Africa, and the Middle East.* Center for Global Development, Working Paper Number 156, December 2008, p. 41.

63 German Aerospace Center (DLR), *Concentrating Solar Power for Desalination*. 2007.

64 Examples of factors that underlie cost comparisons: "Quoted prices for materials and equipment (steel, cement, turbines, electric generators, etc.) can vary considerably across countries and projects. The same is true for the cost of construction, labor and operational and maintenance personnel. Coal, oil, and gas differ in quality and cost, and their future prices are difficult to predict. Full project costs, especially for renewable technologies, are also influenced by the physical characteristics of project sites. In addition, expected profitability, which determines whether or not a project is actually pursued, is affected by electricity tariff structures, tax incentives, renewable portfolio standards, debt-to-equity ratios, finance and insurance arrangements, capital cost schedules, investors' expected returns, and, importantly, expectations about regulation of greenhouse gas emissions." Ummel and Wheeler, 2008.

65 German Aerospace Center DLR: *Concentrating Solar Power for the Mediterranean Region*. April 2005.

66 Kevin Ummel and David Wheeler: *Desert Power: The Economics of Solar Thermal Electric-*

ity for Europe, North Africa, and the Middle East. Center for Global Development, Working Paper Number 156, December 2008.

67 Isabelle Werenfels, Kirsten Westphal: *Solarstrom aus Nordafrika. Perspektiven und Rahmenbedingungen*. Stiftung Wissenschaft und Politik (SWP) 2010, p. 26.

68 Kevin Ummel and David Wheeler: *Desert Power: The Economics of Solar Thermal Electricity for Europe, North Africa, and the Middle East.* Center for Global Development, Working Paper Number 156, December 2008.

69 Greenpeace International, SolarPACES, ESTELA: *Concentrating Solar Power – Global Outlook 2009*, p. 39.

70 However, simply adding a transmission component to the cost per kWh leads to rather inaccurate results for several reasons. Firstly, the transmission lines are likely to be financed separately from the renewables projects in North Africa. Secondly, the cost varies greatly according to a host of factors such the starting and ending point of the lines, whether they will be overhead or underground, how much green electricity is transmitted through them, and myriad other contingencies.

71 Lastly, as there are no HVDC lines across the Mediterranean yet, very little data exists that folds transmission cost into a cost figure per kWh. Currently, a total of 80,000 MW in HVDC transmission capacity is in operation or under construction in over 100 projects around the world, so improved cost data will be forthcoming.

72 Isabelle Werenfels, Kirsten Westphal: *Solarstrom aus Nordafrika. Perspektiven und Rahmenbedingungen*. Stiftung Wissenschaft und Politik (SWP) 2010, p. 26.

73 German Aerospace Center DLR: *Concentrating Solar Power for the Mediterranean Region*, 2005, p. 124.

74 For a good comparison of major studies on the cost of CSP see US Department of Energy: *Report to Congress on Assessment of Potential Impact of Concentrating Solar Power for Electricity Generation*, 2007.

75 Greenpeace International, SolarPACES, ESTELA, *Concentrating Solar Power – Global Outlook 2009*, p. 8.

76 NEEDS New Energy Externalities Developments for Sustainability: *Final report on technical data, costs, and life cycle inventories of solar thermal power plants,* 2008, p. 26.

77 The state of advancement of the project, however, remains unclear.

78 15% of Morocco's electricity imports come from Spain.

79 A new feasibility study was conducted in 2006. The project is linked to the construction of a 1,200MW conventional fossil-fuel power plant in Tunisia.

80 Source: NPI, *Identification Mission for the Mediterranean Solar Plan: Final Report*, January 2010, pp. 27-28.

81 Sources: ESTELA, July 2009; K. Ummel and D. Wheeler (2009), p.20.

82 Sources: ESTELA, July 2009; K. Ummel and D. Wheeler (2009), p.21.

83 Sources: ESTELA, July 2009; K. Ummel and D. Wheeler (2009), p.21.

84 Source: ESTELA, July 2009, p.11.

85 Source: ENTSO-E, Draft for consultation: Ten-Year Network Development Plan 2010-2020,

(March 2010), p. 100.

86 Tom Pfeiffer: *Europe's Saharan power plan: miracle or mirage?* Reuters, August 23, 2009. <http://www.reuters.com/article/idUSTRE57N00920090824>, accessed March 15, 2010.

87 The term was relayed by German business daily Handelsblatt in its coverage of the project's potential mistreatment of African countries. Source: MNN, <http://www.mnn.com/earth-matters/energy/stories/400-billion-euro-plan-to-pump-african-solar-power-to-europe>, accessed March 21, 2010.

88 For instance, see arguments linking DESERTEC to other massive projects like the Trans-Saharan gas pipeline. Source: Daily Observer, <http://www.liberianobserver.com/node/1000>, accessed March 21, 2010.

89 Source: European Commission, <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/10/242&format=HTML&aged=0&language=EN&guiLanguage=en>, accessed March 22, 2010.

90 Mustapha Faid, *The Maghreb Energy Sector: Situation and Perspectives*, 2009, p. 111.

91 Ibid, p. 111.

92 Ibid.

93 Ibid, p. 108.

94 For instance, observers have described Algerian attempts at energy liberalization as "short-lived" featuring legislative reversals and impasses, even when enjoying government support. Source: I. Stein, *EU Energy Policy vis-à-vis Algeria: Challenges and Opportunities*, Bologna Center Journal Of International Affairs, Vol. 13, Spring 2010), <http://bcjournal.org/2008/eu-energy-policy-vis-a-vis-algeria/>, accessed March 21, 2010.

95 This region includes Morocco, Algeria, Tunisia, Egypt, Israel, Jordan, Lebanon, Syria, the Palestinian Authority, and Turkey. Source: European Commission, <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/09/1890&type=HTML>, accessed March 21, 2010.

96 Source: European Commission, <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/09/1890&type=HTML>, accessed March 21, 2010.

97 Source: European Commission: <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/1488&format=HTML&aged=0&language=EN&guiLanguage=en>, accessed March 21, 2010.

98 Source: World Economic Forum, *The Global Competitiveness Report 2009-2010* (2010), p. 309.

99 In early 2007, the Salafist Group for Preaching and Combat aligned itself with Al-Qaeda to form "al-Qaeda in the Land of the Islamic Maghreb". Source: BBC, <http://news.bbc.co.uk/2/hi/africa/6545855.stm>, accessed March 21, 2010.

100 Sources: European Commission (DG TREN), *Statistical Pocketbook 2010 – EU Energy in Figures*, 2.2.3, p. 13; and European Commission, *Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy*, 2006. According to the same study, EU gas imports could increase to 80% by 2030. Note: these figures reflect 2007 levels.

101 European Commission (DG TREN), *Statistical Pocketbook 2010 – EU Energy in Figures*, 2.2.4, p. 14.

102 At that time, Algerian minister of energy Chakib Khelil stated that his country "would continue to respect (its) contractual commitments vis-à-vis (its) customers, as (it) had always done, even at the most difficult times," further noting that the controversy ran the risk of "having a greater negative impact in the long-term on exporters of natural gas via a pipeline". Source: La Liberté, <http://www.redorbit.com/news/science/350217/algerian_energy_minister_sees_negative_impact_from_russian_gas_dispute/index.html>, accessed March 22, 2010.

103 In fact, it is unlikely Algeria could take on a much bigger supply role in light of both its export capacity and booming domestic demand. For a discussion of the current and future limits of Algerian natural gas exports to Europe, see Les Afriques, <http://www.lesafriques.com/en/algeria/russia-ukraine-why-algerian-natural-gas-can-t-come-to-the-rescue.html?Itemid=35?articleid=0213>, accessed March 22, 2010.

104 In the case of Algeria, gas represents 97% of total exports while 90% of its crude oil is sent to Europe. Source: European Commission, <http://europa.eu/rapid/pressReleasesAction.do?reference=SPEECH/06/752&format=HTML&aged=1&language=EN&guiLanguage=en>, accessed March 22, 2010.

105 To this end, many analysts have argued that national support schemes should be replaced by a pan-European support scheme for renewable energy. However, this is both unrealistic and undesirable. Currently, seven Member States support renewable energy through quota obligations and 18 through feed-in-tariffs. It is unlikely that Member States will give up their national systems in exchange for a harmonized European support mechanism, because each national system is deeply entrenched in economical, financial and political path-dependencies. The Commission accepts this and furthermore holds that "the introduction of one harmonized system would create a lot of uncertainty and disruption in the market for renewables, as it would abolish well-established national support schemes." (European Commission Staff Working Document: *The support of electricity from renewable energy sources*. , p. 15).

106 World Bank: *Over $5.5 billion in New Investment for Clean Energy Technology in the Middle East and North Africa Region*, Press Release No:2010/MNA/183, December 9, 2009.

107 Union for the Mediterranean: *Mediterranean Solar Plan, Strategy Paper.* Draft Paper for Discussion, January 14, 2010, p. 5.

108 European Commission, *Green Paper towards a secure, sustainable and competitive European energy network.* COM(2008) 782 final, p. 11.

109 Jeremy van Loon: *Sahara Desert Solar Project Seeks Above-Market Price*. Bloomberg, March 8, 2010.

110 European Commission: *International climate policy post-Copenhagen: Acting now to reinvigorate global action on climate change.* March 10, 2010. COM(2010) 86, p. 10.

111 Jeremy van Loon: *Sahara Desert Solar Project Seeks Above-Market Price*. Bloomberg, March 8, 2010.

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