Partenariat Energétique Tunisie - Allemagne

"Renewable Electricity Expansion in Tunisia"

Renewable Electricity Expansion in Tunisia

Jürgen Kern
Dr. Franz Trieb
Tobias Fichter

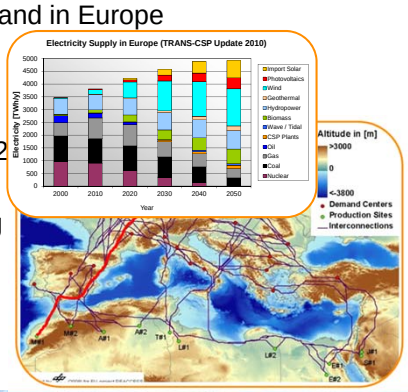
Deutsches Zentrum für Luft- und Raumfahrt e.V.(DLR)
Institut für Technische Thermodynamik
System Analysis and Technology Assessment

Tunis, 29.04.2013

Wissen für Morgen

Solar Electricity Imports from North Africa to Europe

- Quantification of the demand for solar electricity imports providing flexible power and firm capacity for 30 European countries (TRANS-CSP 2006)
- Identification of 300 potential corridors connecting production sites in North Africa with centers of demand in Europe (REACCESS 2009)
- Selection of 30 potential corridors to provide 700 TWh/a to Europe (Trieb et al. Energy Policy 42 (2012
- Selection and detailed description of a first HVDC corridor connecting a large-scale CSP plant in NA with a German center of demand in 2022 (BETTER 2012-2014)



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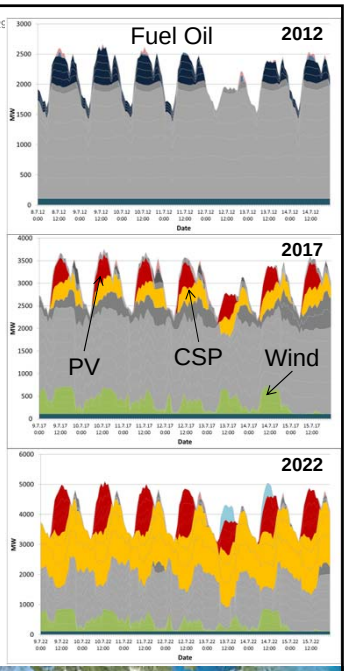
BETTER WP3: North Africa Case Study for Morocco, Tunisia, Egypt, Algeria, Libya

- **3.1. Inventory of RES-E in NA countries (PIK)**
  - **3.1.1. Energy system characterization and RES(-E) deployment**
  - 3.1.2. Energy policy framework
  - 3.1.3. Present Barriers for RES-E market introduction and expansion
  - **3.1.4. Regional grid capacity and grade of interconnection**
- **3.2. Prospects for renewable energy expansion for the NA countries – bottom-up assessment (OME)**
  - **3.2.1. Renewable energy potentials and related costs**
  - **3.2.2. Demand development scenarios**
  - 3.2.3. RES(-E) Policy targets in the short (2020) to long-term (2050) from national/regional viewpoint in NA countries
  - 3.2.4. Estimated framework development
  - **3.2.5. Technologically and economically feasible pathways for RES(-E) deployment**
  - 3.2.6. Environmental and Socio-economic impact assessment
- **3.3. Prospects for renewable energy exports from NA to EU (DLR)**
  - **3.3.1. Grid technology characterisation**
  - **3.3.2. Technical framework conditions**
  - **3.3.3. Role of renewable energy imports in Europe**
  - **3.3.4. Investments required for infrastructure**
  - **3.3.5. Technologically and economically feasible pathways for solar energy export from NA to EU until 2020 and beyond**
  - 3.3.6.: Environmental and Socio-economic impact assessment related to exports
- **3.4. Role and Design of the Cooperation Mechanisms (DLR)**
  - 3.4.1. Economic framework for the integration of renewable electricity in North Africa
  - 3.4.2. Economic framework for the integration of renewable electricity imports from North Africa to Europe
  - 3.4.3: Compatibility with other instruments
  - 3.4.4: Design of the mechanisms
  - 3.4.5: Assessment of the possible role of the cooperation mechanism from a host-country perspective
- **3.5. SWOT Analysis EU-North Africa with Energy Security Assessment (PIK)**
  - 3.5.1. Analysis of energy security risks related with the use of cooperation mechanisms
  - 3.5.2. Analysis of the weaknesses with regard to cooperation mechanisms
  - 3.5.3. Analysis of the strengths with regard to cooperation mechanisms
  - 3.5.4. Analysis of the opportunities with regard to cooperation mechanisms
- **3.6. Preparation of a case study report that summarizes results of WP3 (DLR)**

RES-E Expansion in MENA

Strongly required firm and flexible power capacity to cope with growing demand

- PV and wind power are inexpensive "fuel savers" but do not provide firm power capacity
- Very limited availability of electricity storage and other flexible and firm RES-E like biomass or hydropower.
- CSP competitive in the peak and upper-mid merit segment to substitute firm capacity from fuel oil
- In the medium-term CSP competitive in mid-merit and base load segment to substitute firm capacity from gas and coal.
- CSP in long-term as back-bone of electricity supply complemented by wind power and PV.



Example Jordan 2012:

Source: REMix-CEM, T. Fichter et al., DLR (2012)

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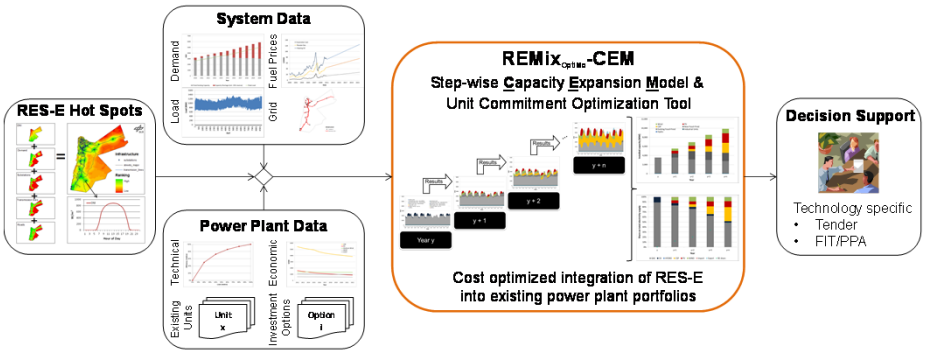
Methodology for an optimized integration of RES-E technologies into existing power plant portfolios in MENA

- Emphasis on cost-optimized short-term integration of renewable energy systems for electricity generation (RES-E) and on security of supply
- Results for decision support for electricity authorities and power utilities in MENA



Source: REMix-CEM, T. Fichter et al., DLR (2012)

Policy Database for REMix-CEM

Moroccan Solar Plan
RES4MED
Clean Technology Fund
Tunisian Solar Plan
EC RE Directive April 2009
DESERTEC Initiative
Tunisian-German-Energy Partnership
Union for the Mediterranean
Mediterranean Solar Pl
Partnership
We will try to provide an overview for peer review before July 2013
Morocco-Germa
MED-REG
MENA CSP Scale-up Initiative
CTF CSP MENA Investment Plan
MEDGRID Initiative
MED-TSO
MED-ENEC
Algerian Master Plan
Paving the way for the Mediterranean Solar Plan

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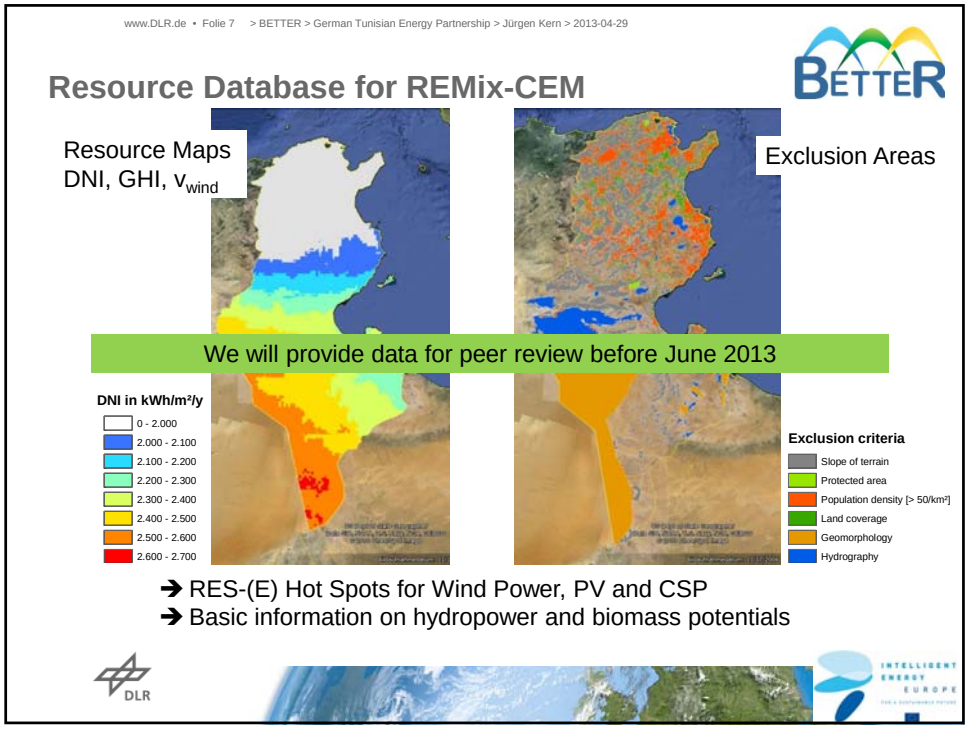

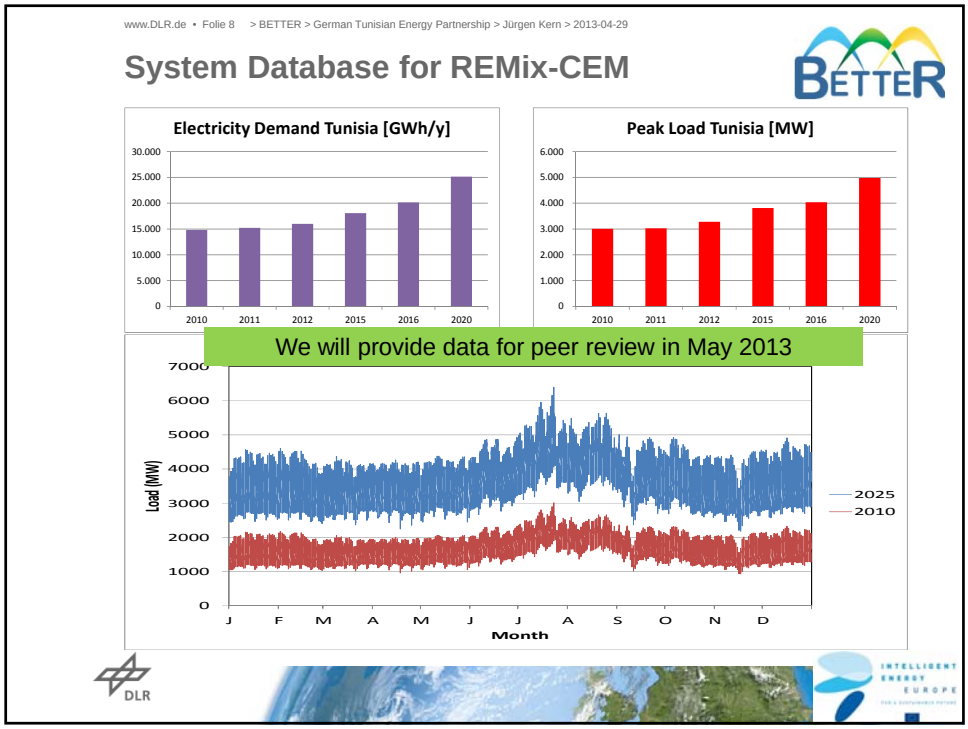

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Power Plant Database for REMix-CEM

Name of power station according to WEPP	Name of power station according to AUE	Operating company	Number of blocks	Status	Name of location / nearest City	First year of operation according to WEPP	First year of operation according to AUE	Type of power plant	Primary fuel	Alternative fuel	Cooling system	Installed capacity - gross (WEPP) [MW]	Installed capacity - gross (AUE) [MW]	Maximum ramp rate of turbine [% of capacity - gross/min]	Minimum power generation level [% of capacity - gross]	Time start up (hot) [h]	Time start-up (warm) [h]	Time start-up (cold) [h]	Minimum online time [h]	Minimum offline time [h]	Fuel use - start-up [MWh$_{th}$/MW]
Bellli mill GT 1			1 OPR	Bellli		2006		OCGT	GAS			6,2		20%	20%	0	0	0	0	0	1,1
Bir Kassaa Factory 1			1	Bir El Kenssa		1963		ST				1,5		5%	20%	3	5	60	15	15	4,5
Fir M'Cherga GT 1	GT PS / BirMcherga	STEG	1 OPR	Bir m'Cherga		1997	1997	OCGT	GAS	LFO		120	118	8%	20%	0	0	0	0	0	1,1
Fir M'Cherga GT 2	GT PS / BirMcherga	STEG	1 OPR	Bir m'Cherga		1997	1997	OCGT	GAS	LFO		120	118	8%	20%	0	0	0	0	0	1,1
Bouchemma GT 1	GT PS / Bouchemma	STEG	1 OPR	Bouchemma		1976	1977	OCGT	GAS			27	31	20%	20%	0	0	0	0	0	1,1
Bouchemma GT 2	GT PS / Bouchemma	STEG	1 OPR	Bouchemma		1976	1978	OCGT	GAS			27	31	20%	20%	0	0	0	0	0	1,1
Bouchemma GT 3	GT PS / Bouchemma	STEG	1 OPR	Bouchemma		1999	1998	OCGT	GAS			118	118								1,1
El Biban GT 1			1 OPR	Zarzis		2003		OCGT	GAS			13,5									1,1
El Biban GT 2			1 OPR	Zarzis		2003		OCGT	GAS			13,5									1,1
El Borma GT 1			1 OPR			1997		OCGT	GAS			14									1,1
El Borma GT 2			1 OPR			1997		OCGT	GAS			14									1,1
El Borma GT 3			1 OPR			1997		OCGT	GAS			14									1,1
El Fouledh works 1			1	Bourguiba		1963		ST				3									4,5
El Haouaria CC			1 PUN	El Haouaria		2014		CCGT	GAS			1200									3,5
Feriana GT 1	GT PS / Feriana	STEG	1 OPR	Feriana		2004	2005	OCGT	GAS	LFO		120	118								1,1
Feriana GT 2	GT PS / Feriana	STEG	1 OPR	Feriana		2010	2009	OCGT	GAS	LFO		126	118								1,1
Feriana Snamprogetti GT 1			1 OPR	Feriana		1994		OCGT	GAS	LFO		1,48									1,1
Ghannouch CC 1	CentraleGhennouch (CC)	STEG	1 OPR	Ghannouch		2011	2011	CCGT	GAS		Sea water	400	415								3,5
Ghannouch GT 1			1 OPR	Ghannouch		1973		OCGT	LFO			15									1,1
Ghannouch GT 2	GT PS / Ghannouch	STEG	1 OPR	Ghannouch		1975	1973	OCGT	GAS			22,2	22								1,1
Ghannouch GT 3	GT PS / Ghannouch	STEG	1 OPR	Ghannouch		1975	1973	OCGT	GAS			22,2	22								1,1
	ST PP / Ghannouch	STEG	1				1972	ST					30								4,5
	ST PP / Ghannouch	STEG	1				1972	ST			Sea water		30								4,5
ICM chemical plant 1			1 OPR	Gabes		1974		ST			Sea water	8									4,5
ICM ch																					
Kasser																					
Kasser																					
Korba																					
Korba																					
La Gou																					
La Gou																					
La Skh																					
M'Dilla Acid plant 1			1 OPR	M'dilla		1983		ST				15,2									4,5
M'Dilla Acid plant 2			1 OPR	M'dilla		1983		ST				15,2									4,5
Metlaoui GT 1	GT PS / MenzelBourguiba	STEG	1 OPR	Metlaoui		1979	1978	OCGT	LFO			21,5	22								1,1
Metlaoui GT 2	GT PS / MenzelBourguiba	STEG	1 OPR	Metlaoui		1979	1978	OCGT	LFO			21,5	22								1,1
Rades A1	ST PP / Rades 1A	STEG	1 OPR	Rades		1986	1985	ST	HFO	GAS	Sea water	170	170								4,5
Rades A2	ST PP / Rades 1A	STEG	1 OPR	Rades		1986	1985	ST	HFO	GAS	Sea water	170	170								4,5
Rades B1	ST PP / Rades 1B	STEG	1 OPR	Rades		1998	1988	ST	HFO	GAS	Sea water	170	180								4,5
Rades B2	ST PP / Rades 1B	STEG	1 OPR	Rades		1998	1988	ST	HFO	GAS	Sea water	170	180								4,5
Rades Carthage CC	Centrale Rades 2 (1 P J) (CC)	STEG	2+1 OPR	Zone Petrolliere c		2002	2002	CCGT	GAS	LFO	Sea water	480	470								3,5
Rhennouch 1			1 OPR			1972		ST	GAS	HFO		30									4,5
Rhennouch 2			1 OPR			1972		ST	GAS	HFO		30									4,5
Robbana GT 1	GT PS / Robbana	STEG	1 OPR			1983	1984	OCGT	LFO			31	34								1,1
Sawpa Nitric plant 1			1 OPR	Gabes		1979		ST	HFO			20									4,5
Sawpa Nitric plant 2			1 OPR	Gabes		1984		ST	HFO			7,92									4,5
Sfax Barc GT 1			1 OPR			1994		OCGT	GAS			27,4									1,1
Sfax Barc GT 2			1 OPR			1994		OCGT	GAS			27,4									1,1
Sfax Barc CC			1 PUN			2014		CCGT	GAS			500									3,5
Sfax FertiSuer 1			1 OPR			1964		ST				1,5									4,5
Sfax STEG GT 1	GT PS / Sfax	STEG	1 OPR			1979	1977	OCGT	LFO			21,5	22	20%	20%	0	0	0	0	0	1,1
Sfax STEG GT 2	GT PS / Sfax	STEG	1 OPR			1980	1977	OCGT	LFO			21,5	22	20%	20%	0	0	0	0	0	1,1
Sousse I 1	Centrale Thermique de Sous	STEG	1 OPR	Sousse		1979	1980	ST	HFO		Sea water	160	160	5%	35%	3	5	60	15	15	4,5
Sousse I 2	Centrale Thermique de Sous	STEG	1 OPR	Sousse		1979	1980	ST	HFO		Sea water	160	160	5%	35%	3	5	60	15	15	4,5
Sousse II CC	CentraleSousse B (CC)	STEG	2+1 OPR	Sousse		1994	1995	CCGT	GAS		Sea water	357	364	4%	25%	1	2	4	6	6	3,5
Sousse III CC			PUN	Sousse		2013		CCGS	GAS			400		9%	15%	0	1	2	2	4	3,5
Teqa Riverte CC			PUN			2014		CCGT	GAS			500		9%	15%	0	1	2	2	4	3,5
Thyna GT 1	GT PS / Thyna	STEG	1 OPR	Thyna		2004	2004	OCGT	GAS	LFO		120	118	8%	20%	0	0	0	0	0	1,1
Thyna GT 2	GT PS / Thyna	STEG	1 OPR	Thyna		2007	2007	OCGT	GAS	LFO		123	118	8%	20%	0	0	0	0	0	1,1
Thyna GT 3	GT PS / Thyna	STEG	1 OPR	Thyna		2010	2010	OCGT	GAS	LFO		123	118	8%	20%	0	0	0	0	0	1,1
Tunis Sud GT 1	GT PS / Tunis - Sud	STEG	1 OPR	Tunis		1977	1975	OCGT	LFO			21,75	22	20%	20%	0	0	0	0	0	1,1
Tunis Sud GT 2	GT PS / Tunis - Sud	STEG	1 OPR	Tunis		1977	1975	OCGT	LFO			21,75	22	20%	20%	0	0	0	0	0	1,1
	GT PS / Tunis - Sud	STEG	1				1978	OCGT	GAS				22	20%	20%	0	0	0	0	0	1,1
Zarzis GT 1	GT PS / Zarzis	STEG	1 OPR	Zarzis		1999	1984	OCGT	LFO			31	34	20%	20%	0	0	0	0	0	1,1

Please review the Excel Sheet provided in April 2013
and give us feedback in Mai 2013!

Grid Database for REMix-CEM

- Power Lines:
  - 400 kV AC
  - 225 kV AC
  - 30 kV AC
- Transformer Stations

We will provide data for peer review before May 2013

Geographic Information System

- (*.kmz files)

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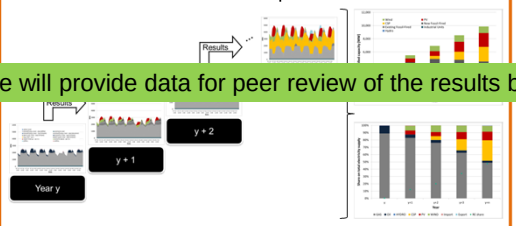
REMix-CEM – Decision Support

- On the basis of this information, REMix-CEM will provide a model for cost-optimized integration of RES-E in Tunisia and the other North African countries in the short, medium and long term.

REMix$_{OptiMo}$-CEM

Step-wise **C**apacity **E**xpansion **M**odel &
Unit Commitment Optimization Tool



Cost optimized integration of RES-E
into existing power plant portfolios

Decision Support

Technology specific
- Tender
- FIT/PPA

We will provide data for peer review of the results before November 2013

Source: REMix-CEM, T. Fichter et al., DLR (2012)

- **CIEMAT** - *Centro de Invest. Energ. Mediamb. Tecn (Spain)*
- **DLR** – *Deutsches Zentrum Für Luft-und raumfahrt e.V (Germany)*
- **ECN** – *Energy Research Centre of the Netherlands (Netherlands)*
- **JOANNEUM** – *Forshungsgesellschaft Mbh (Austria)*
- **NTUA** – *National Technical University of Athens (Greece)*
- **OME** – *Observatoire Mediterranéen de l´Energie (France- Int.)*
- **PIK** – *Postdam Institute for Climate Impact Research (Germany)*
- **TUWIEN** – *Vienna University of Technology (Austria)*
- **UNDP** – *United Nations Development Programme (International)*

Thank you for your attention!

Franz.Trieb@dlr.de
Tobias.Fichter@dlr.de
Massimo.Moser@dlr.de
Juergen.Kern@dlr.de
Denis.Hess@dlr.de