QatDLR Workshop Doha
18th of November 2013

QatDLR Status November 2013

WP1: Framework for sustainable energy supply of Qatar and the Arabian Peninsula

Jürgen Kern, Franz Trieb, Tobias Fichter, Steffen Stökler

German Aerospace Center (DLR)
Institute of Technical Thermodynamics (Stuttgart)
Department of Systems Analysis and Technology Assessment

DLR

Work Package (WP) 1:

Title:

Technical and economic frame conditions for efficient and sustainable energy supply in Qatar and the Arabian Peninsula

Structure:

AP 1.1: Resource potentials

AP 1.2: Techno-economic Potentials

AP 1.3: Market potentials

AP 1.4: Frame conditions

AP 1.5: Socio-economic impact

AP 1.6: Environmental impact

DLR

QatDLR Workshop Doha
18th of November 2013

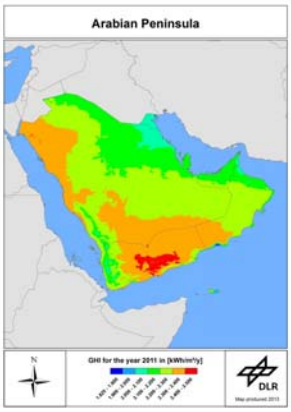
AP 1.1: Resource Potentials

Topics: Mapping of energy sources and energy infrastructure

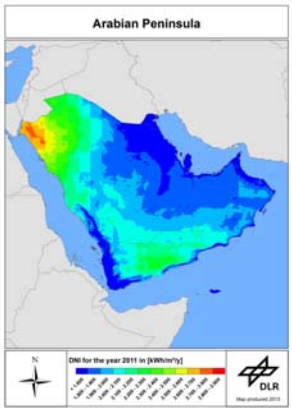
- Global Radiation ✓
- Direct-Normal-Radiation ✓
- Wind Power ✓
- Hydropower ✓
- Geothermal ✓
- Biomass ✓
- Fossil Energy Carriers (Oil, Gas) ✓
- Uranium ✓
- Infrastructure for exploitation and distribution of energy sources (Electricity grid, power plants, pipelines, etc.) ✓

Mapping of Energy Resources
Examples

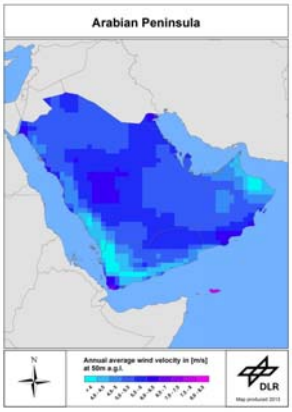
GHI in 2011
(more years in work



DNI in 2011
(more years in work)



Ø Wind Speed @ 50m
1984 - 2005



QatDLR Workshop Doha
18th of November 2013

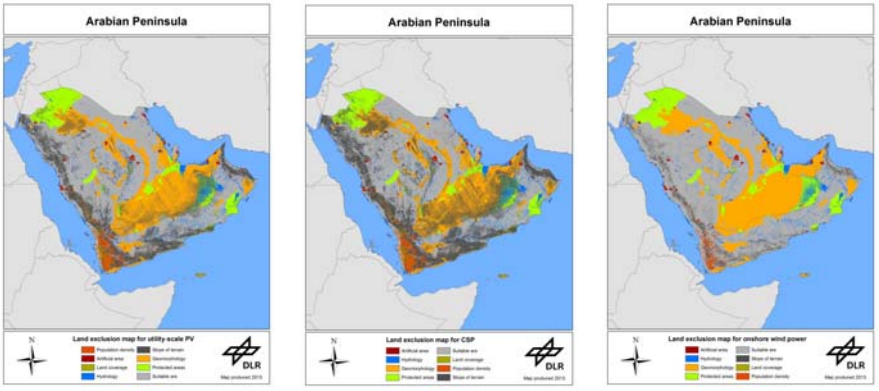
AP 1.2: Technical and Economic Potentials

Topics:

- Area restrictions for renewable energy systems. ✓
- Definition of technical and economic thresholds of utilizability and exploitability of energy potentials. ✓
- Quantification of available energy potentials by technology. ✓
- Geografic infrastructure database. ✓
- Site-Ranking-Maps: geographic distribution of energy resources and ranking of sites.

Technical and Economic Potentials
Example: technology-specific exclusion maps

Large-scale PV | **CSP** | **Wind**



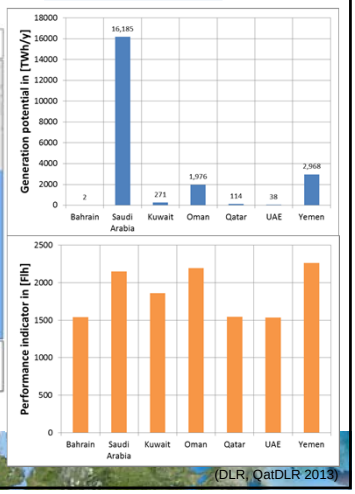
QatDLR Workshop Doha
18th of November 2013

Technical and Economic Potential
Example: Potential of wind energy

Exclusion Areas → Resource availability → Statistical evaluation

(DLR, QatDLR 2013)

(DLR, QatDLR 2013)



(DLR, QatDLR 2013)

Country specific power plant database

Data base: ca. 3000 units

DLR - Power Plant Database

Country:	**Saudi Arabia**
Developed by:	Tobias Fichter Tobias.Fichter@dlr.de
	Anna-Lena Fuchs Anna-Lena.Fuchs@dlr.de
	2013.10.02.
Table 1	Thermal Power Plants
Table 2	Wind Power Plants / Sites
Table 3	Solar Power Plants

CCGT combined cycle gas turbine
ST steam turbine
OCGT open cycle gas turbine
IC internal combustion engine

Data ID	Country	Subject	Name (Full)	Name (Short)	ADM1 Level	ADM2 Level	Status	Technology	Fuel	Cooling	Combined Heat and Power	Installed Gross Capacity in MW
53	Saudi Arabia	Powerstation	AL-JOUF OCGT 1	AJO-OCGT-1	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	34
54	Saudi Arabia	Powerstation	AL-JOUF OCGT 2	AJO-OCGT-2	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	34
55	Saudi Arabia	Powerstation	AL-JOUF OCGT 3	AJO-OCGT-3	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	34
56	Saudi Arabia	Powerstation	AL-JOUF OCGT 4	AJO-OCGT-4	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	34
57	Saudi Arabia	Powerstation	AL-JOUF OCGT 5	AJO-OCGT-5	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	34
58	Saudi Arabia	Powerstation	AL-JOUF OCGT 6	AJO-OCGT-6	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	34
59	Saudi Arabia	Powerstation	AL-JOUF OCGT 7	AJO-OCGT-7	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	34
60	Saudi Arabia	Powerstation	AL-JOUF OCGT 8	AJO-OCGT-8	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	55.5
61	Saudi Arabia	Powerstation	AL-JOUF OCGT 9	AJO-OCGT-9	Al Jawf	Al-Jouf City	OPR	OCGT	LFO/CR		no	55.5
62	Saudi Arabia	Powerstation	AL-JUAYMAH IC 4	AJU-IC-4	Ash Sharqiyah	Al-Juaymah	OPR	IC	LFO		no	10.8
63	Saudi Arabia	Powerstation	AL-JUAYMAH OCGT 1	AJU-OCGT-1	Ash Sharqiyah	Al-Juaymah	OPR	OCGT	GAS		no	30.9
64	Saudi Arabia	Powerstation	AL-JUAYMAH OCGT 2	AJU-OCGT-2	Ash Sharqiyah	Al-Juaymah	OPR	OCGT	GAS		no	63.9
65	Saudi Arabia	Powerstation	AL-JUAYMAH OCGT 3	AJU-OCGT-3	Ash Sharqiyah	Al-Juaymah	OPR	OCGT	GAS		no	63.9
66	Saudi Arabia	Powerstation	AL-JUBAIL (RCJY) OCGT 1	AJB-OCGT-1	Ash Sharqiyah	Al-Jubail	RET	OCGT	DIST		no	23.44
67	Saudi Arabia	Powerstation	AL-JUBAIL (RCJY) OCGT 2	AJB-OCGT-2	Ash Sharqiyah	Al-Jubail	RET	OCGT	DIST		no	23.44
68	Saudi Arabia	Powerstation	AL-JUBAIL IWPP CCGT	AJB-CCGT	Ash Sharqiyah	Al-Jubail		CCGT/D	GAS		yes	1100
69	Saudi Arabia	Powerstation	AL-JUBAIL REFINERY ST 1	AJBR-ST-1	Ash Sharqiyah	Al-Jubail	OPR	ST/S	OIL		yes	5
70	Saudi Arabia	Powerstation	AL-JUBAIL REFINERY ST 2	AJBR-ST-2	Ash Sharqiyah	Al-Jubail	OPR	ST/S	OIL		yes	5
71	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 IC 1	AJBS-IC-1	Ash Sharqiyah	Al-Jubail	STN	IC	DIST		no	3.31
72	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 IC 2	AJBS-IC-2	Ash Sharqiyah	Al-Jubail	STN	IC	DIST		no	3.31
73	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 IC 3	AJBS-IC-3	Ash Sharqiyah	Al-Jubail	STN	IC	DIST		no	3.31
74	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 OCGT 1	AJBS-OCGT-1	Ash Sharqiyah	Al-Jubail	OPR	OCGT	GAS		no	25
75	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 OCGT 2	AJBS-OCGT-2	Ash Sharqiyah	Al-Jubail	OPR	OCGT	GAS		no	25
76	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 OCGT 3	AJBS-OCGT-3	Ash Sharqiyah	Al-Jubail	UNK	OCGT	DIST		no	10
77	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 OCGT 4	AJBS-OCGT-4	Ash Sharqiyah	Al-Jubail	UNK	OCGT	DIST		no	10
78	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 ST 1	AJBS-ST-1	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	60
79	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 ST 2	AJBS-ST-2	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	60
80	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 ST 3	AJBS-ST-3	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	60
81	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 ST 4	AJBS-ST-4	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	60
82	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 ST 5	AJBS-ST-5	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	60
83	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-1 ST 6	AJBS-ST-6	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	60
84	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 01	AJBS-ST-01	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	132.3
85	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 02	AJBS-ST-02	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	132.3
86	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 03	AJBS-ST-03	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	132.3
87	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 04	AJBS-ST-04	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	132.3
88	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 05	AJBS-ST-05	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	132.3
89	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 06	AJBS-ST-06	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	132.3
90	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 07	AJBS-ST-07	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	127.5
91	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 08	AJBS-ST-08	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	127.5
92	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 09	AJBS-ST-09	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	127.5
93	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 10	AJBS-ST-10	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	127.5
94	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 11	AJBS-ST-11	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	127.5
95	Saudi Arabia	Powerstation	AL-JUBAIL SWCC-2 ST 12	AJBS-ST-12	Ash Sharqiyah	Al-Jubail	OPR	ST/D	GAS		yes	127.5

QatDLR Workshop Doha
18th of November 2013

AP 1.3: Market potentials

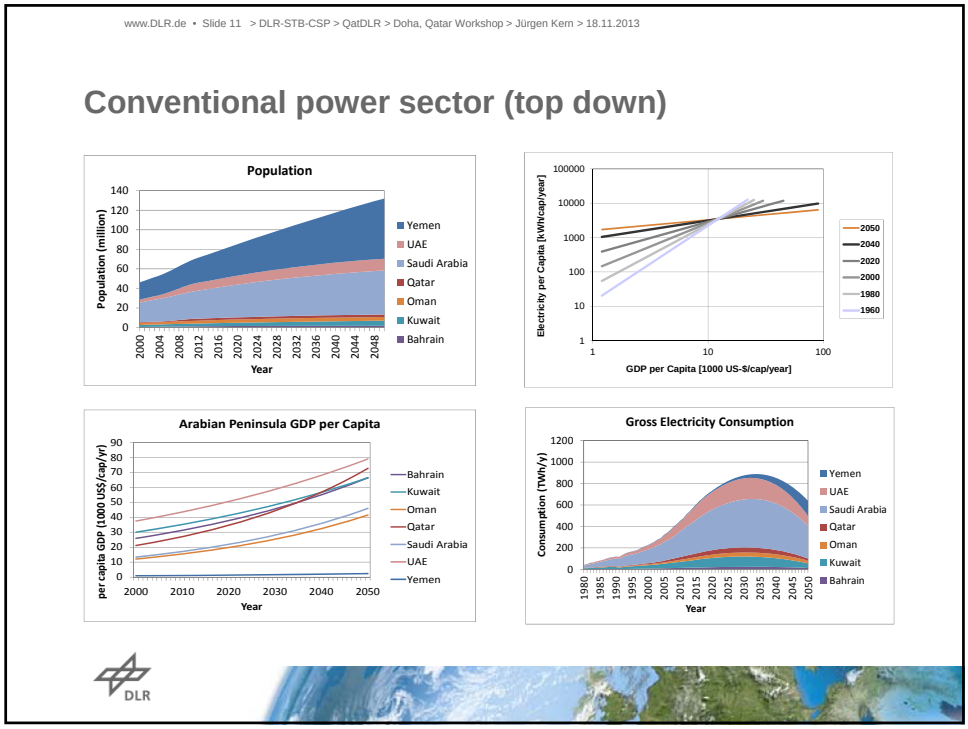
Topics:

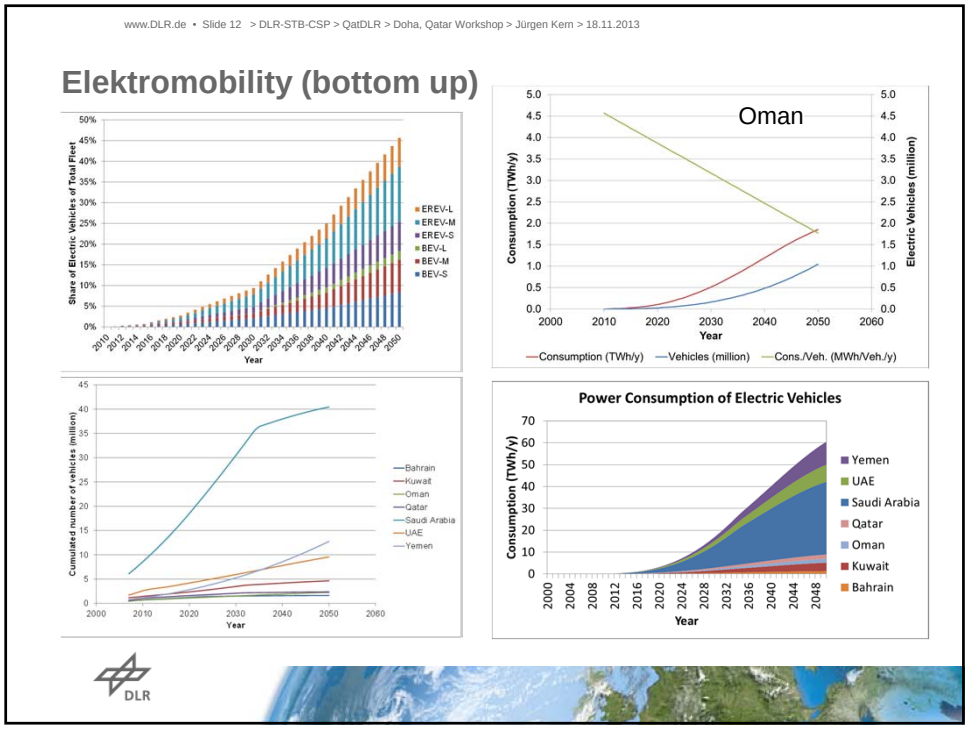
- Demand perspectives for electricity under consideration of additional demand from water supply and the mobility sector. ✓
- Representative electricity load curves under consideration of water supply and the mobility sector. ✓
- Time-specific supply patterns of renewable energy sources. ✓
- Modeling a transition of energy infrastructure towards a secure, inexpensive and sustainable supply pating from today's status quo. ✓
- National scenarios from the year 2000 to 2050 for the power supply system of the seven countries of the Arabian Peninsula. ✓

AP 1.3: Market Potential
Electricity Demand Model

- Conventional electricity sector
  - incl. oil & gas sector
  - incl. heating & cooling (top down analysis)
  - historical data update until 2010 and expectations until 2020 (AUE and National Plans)
- Electromobility (new sector, bottom up analysis 2015+)
- Solar desalination (new sector, bottom up analysis 2015+)

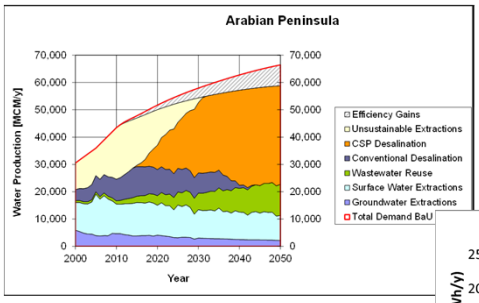
QatDLR Workshop Doha
18th of November 2013





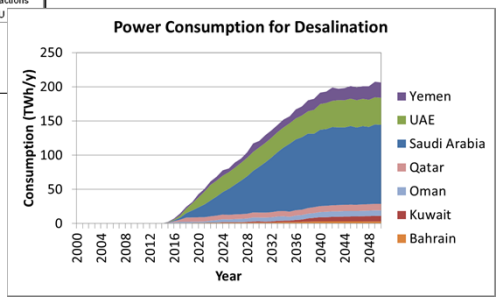
QatDLR Workshop Doha
18th of November 2013

Solar Desalination (bottom up)



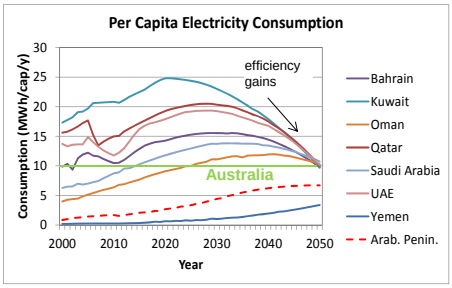
Demand drivers:

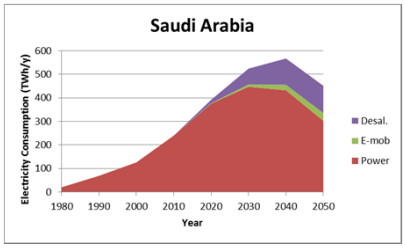
- Population growth
- Efficiency of ater supply system
- Climate change (modelled by futurewater in the MENA Regional Water Outlook study)

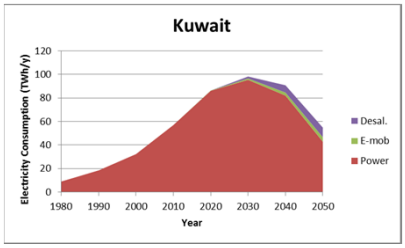


Base load electricity from CSP for RO or electricity loss using thermal distillation in combined heat and power plants

Individual Country Analysis

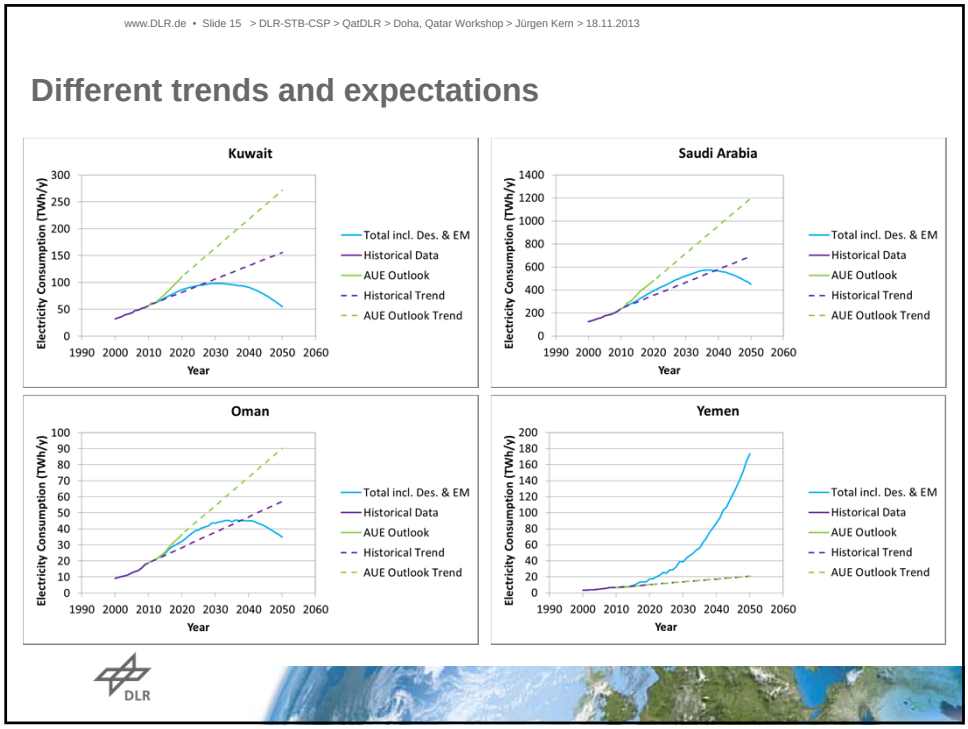


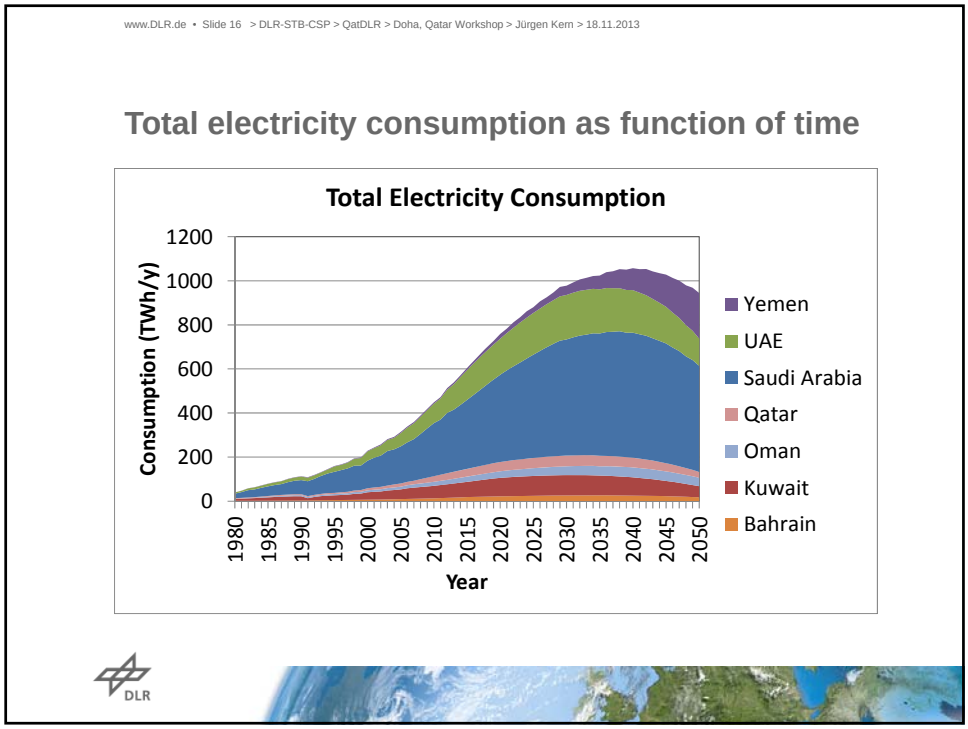




Including demand drivers population, economic growth, heating & cooling, seawater desalination, electromobility and efficiency gains

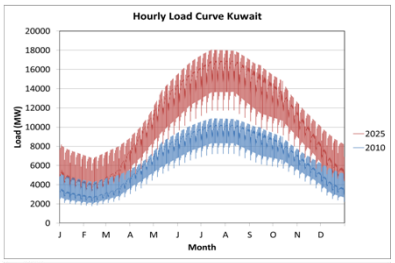
QatDLR Workshop Doha
18th of November 2013

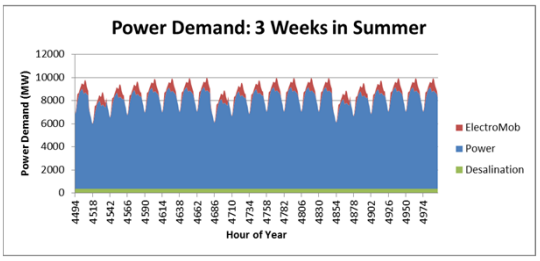


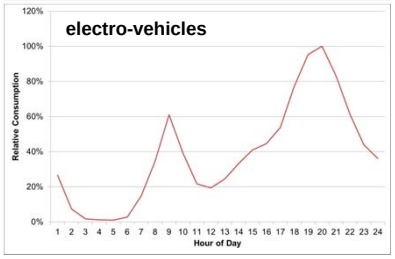


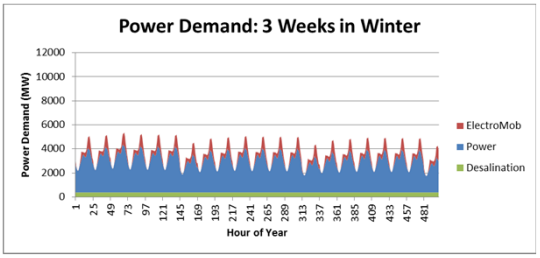
QatDLR Workshop Doha
18th of November 2013

Influence on Load Curves (example Kuwait)









AP 1.3: Market Potential
Criteria for Scenario Development

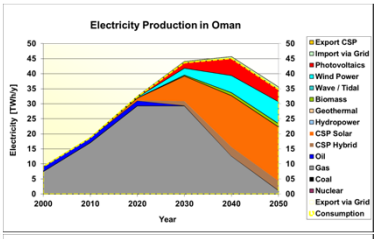
1. **Affordability**
   - Low cost
   - No subsidies
   - Low structural effort
2. **Security**
   - Diversification of supply
   - Power on demand and redundancy
   - Sustainable energy resources
   - Available technology
3. **Environmental compatibility**
   - Low pollution and climate protection
   - No new risks for health and nature
   - Low land use and structural impacts
4. **Social compatibility**
   - Fair access to energy
   - Balance of dependencies and interdependencies
   - Strategic flexibility

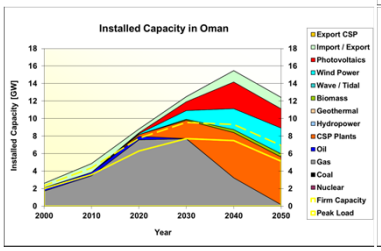
➔ One consistent pathway towards sustainable supply under specific limitations

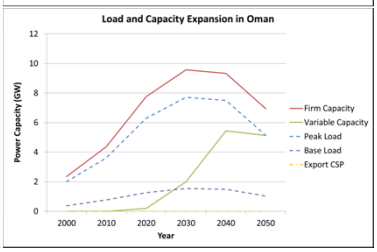
QatDLR Workshop Doha
18th of November 2013

AP 1.3: Market Potential
Country Scenarios 2000 - 2050

- Saudi Arabia ✓
- Kuwait ✓
- Oman ✓
- United Arab Emirates
- Qatar
- Bahrain
- Yemen

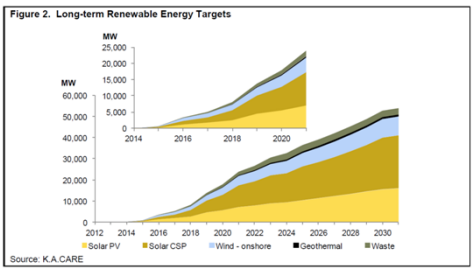






AP 1.4: Regulatory Frame Conditions

- Review of renewable energy policies and regulatory framework conditions in the countries of the Arabian Peninsula
- National renewable energy action plans (NREAPS)
- Renewable energy expansion programs and initiatives
- Documents and publications
- Saudi Arabia ✓
- Kuwait ✓
- Oman ✓
- United Arab Emirates
- Qatar
- Bahrain
- Yemen



QatDLR Workshop Doha
18th of November 2013

Remaining Work Packages and Next Steps

Remaining Work Packages:

- WP 1.5: Socio-economic impact
- WP 1.6: Environmental impact

Next Steps for WP 1.1 -1.4:

- Assess further years of resource data for DNI and GHI
- Produce map of geothermal and biomass potentials
- Assess CSP and large scale PV potentials
- Finalize geo-referenced energy infrastructure database
- Produce site-ranking-maps for PV, CSP and Wind
- Create Scenarios 2000-2050 for UAE, Qatar, Bahrain und Yemen

Final Report QatDLR WP1: 7 Country reports including all results

Selected publications

- MED-CSP www.dlr.de/tt/med-csp
- TRANS-CSP www.dlr.de/tt/trans-csp
- AQUA-CSP www.dlr.de/tt/aqua-csp
- MED-CSD www.med-csd-ec.eu/eng/
- MENA Regional Water Outlook www.dlr.de/tt/menawater
- Financing concentrating solar power in the Middle East and North Africa – Subsidy or investments? Energy Policy 39 (2011) 307-317 http://dx.doi.org/10.1016/j.enpol.2010.09.045
- Solar electricity imports from Middle East and North Africa to Europe Energy Policy 42 (2012) 341-353 http://dx.doi.org/10.1016/j.enpol.2011.11.091

QatDLR Workshop Doha
18th of November 2013

Contact

Jürgen Kern	juergen.kern@dlr.de	+49 711 6862 - 8119
Dr. Franz Trieb	franz.trieb@dlr.de	+49 711 6862 - 423
Tobias Fichter	tobias.fichter@dlr.de	+49 711 6862 - 779
Massimo Moser	massimo.moser@dlr.de	+49 711 6862 - 334

Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
Institut für Technische Thermodynamik
System Analyse und Technologie Bewertung
Pfaffenwaldring 38-40 | 70569 Stuttgart | Germany

www.DLR.de/tt/