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Technical & Financial Aspects for Integrating Large Scale Renewable Energy in Electric Grids

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Expert Group Meeting on: «The Role of Energy Networks in Regional Integration», 22-22 December 2009, Beirut

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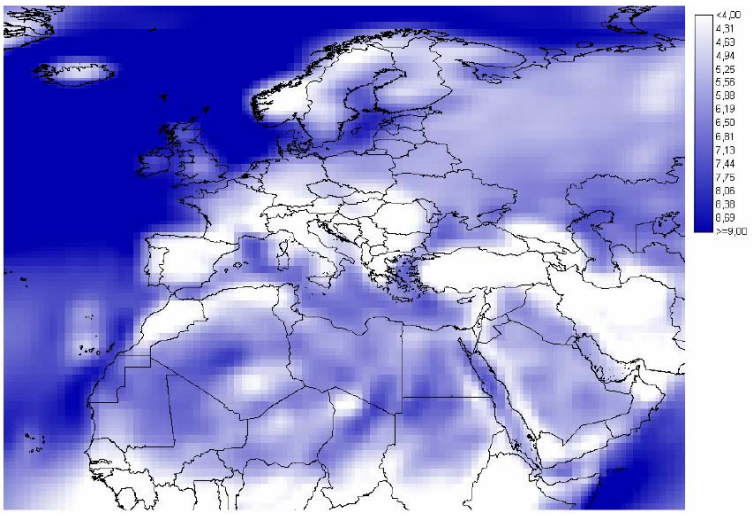
Renewable Energy Resources

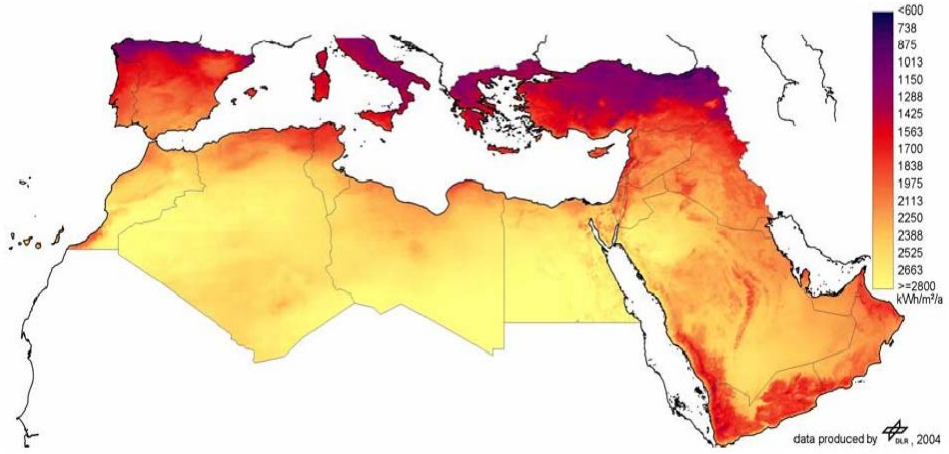
- Large Scale Renewable Energy Valid for Electricity Generation:
  - Wind Energy
    - On Shore
    - Off Shore
  - Solar Energy
    - Concentrated Solar Power (CSP)
      - Parabolic Trough Systems
      - Linear Fresnel Systems
      - Power Tower
    - Photovoltaic (PV)
  - Biomass
    - Incineration
    - Biogas
  - Geothermal
  - Hydro Power: Well Established

Wind Energy: Annual Average Wind Speed



Source: "Concentrating Solar Power for the Mediterranean Region",
DLR for the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany (2005)

Solar Resources: Direct Normal Irradiance



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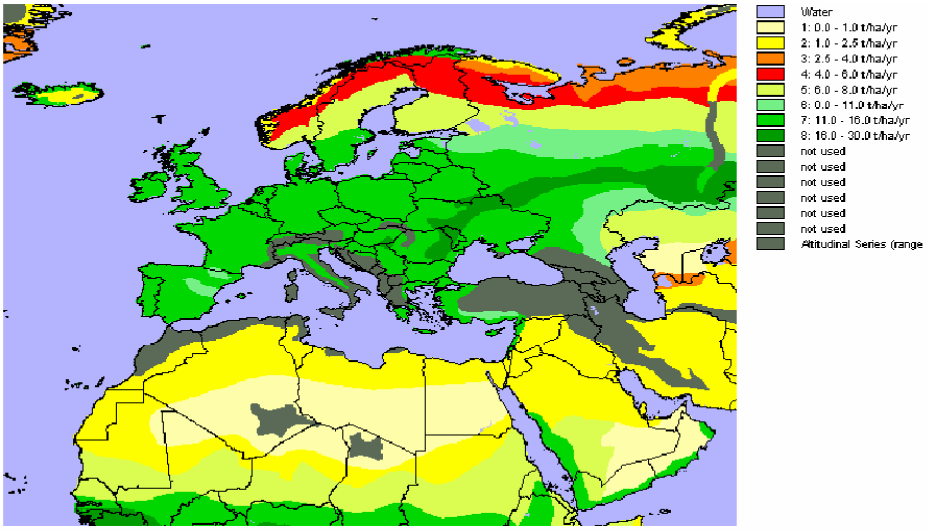
Biomass Productivity



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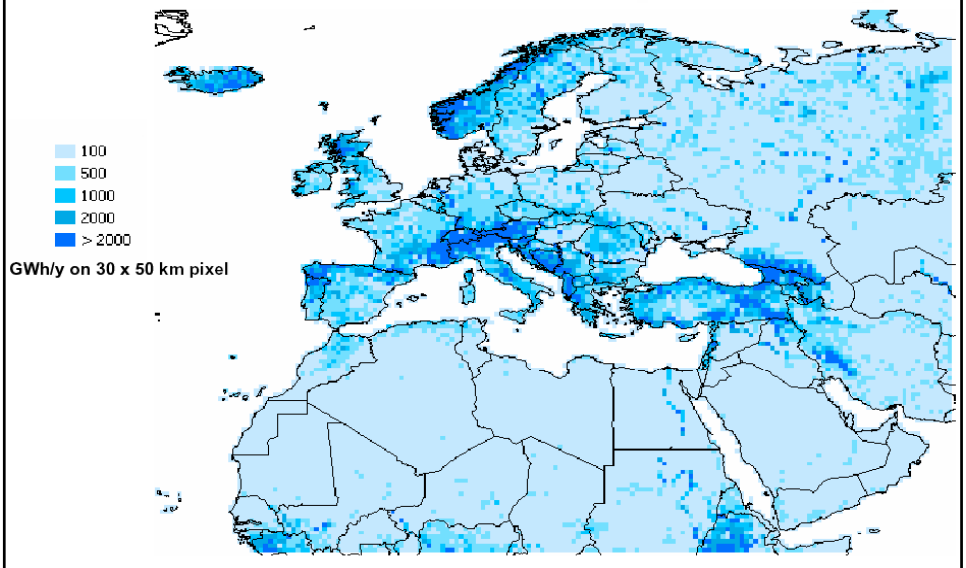
Hydropower Potentials



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Large Scale Renewable Energy Applications in the Region

- Wind Energy:
  - Egypt: 430 MW in 2009.
  - Morocco: 124 MW in 2008
  - Tunisia: 20 MW in 2008
  - Jordan: plans for 600 megawatts in 2020.
  - Yemen has a 60MW wind farm in the development phase.

Large Scale Renewable Energy Applications in the Region

- Solar Energy
  - large scale CSP projects (under construction) "Integrated Solar Combined Cycle, ISCC"
    - Egypt: of 140 MW with 20MW solar share expected by late 2010.
    - Morocco: 470 MW with 20 MW solar share
    - Algeria: 150 MW with 25 MW solar share
  - Egypt intends to build two new CSP projects with 50 MW each, as well as 20 MW large-scale grid connected PV plant in south Egypt by the year 2017.
  - Kuwait has completed a technical feasibility study for the construction of a solar thermal power plant with a capacity of 280 MW including 60 MW solar component.
  - The United Arab Emirates, Abu Dhabi Company for Future Energy, known as the "Masdar":
    - already connected a 10 MW PV plant to the grid,
    - expects the 100 MW Shams 1 CSP plant to be on-line by late 2011,
    - expects the Shams 2 plant by mid-2013.
    - studying the feasibility of the establishment of some plants to produce solar electricity and desalinated water from 500 MW solar plants in Arab countries or abroad.

Large Scale Renewable Energy Applications in the Region

- OPEC Fund for Global Warming:
  - In November 2007, the Gulf countries of the Organization of Petroleum Exporting Countries (OPEC) pledged a total of US$750 million to a new fund to tackle global warming
  - Kuwait, Qatar, and the UAE pledged US$150 million each for the fund.
  - Saudi Arabia, the world's biggest oil exporter, will invest US$300 million in the fund

Large Scale Renewable Energy – Challenges

- Technology standards
- Incentives for governments and private companies
- Financing
- Tariffs and energy markets
- Permits and clearances
- Skills and awareness
- Capacity Building & Technology Transfer

Large Scale Renewable Energy – Barriers

- High Capital to O&M Cost Ratio
- High Project Development to Investment Cost Ratio
- Difficulty Guaranteeing Project Cash Flow
- Weak Basis for Non-Recourse Financing
- Inaccurate Perception of Risk
- Weak Project Developers

Technical Aspects for Integrating Large Scale Renewable Energy

- Engineering Requirements
  - Voltage
  - Frequency
  - Ability to rapidly isolate faults
  - Reasonable ability to withstand abnormal system operating conditions
  - Reasonable ability to actively contribute to voltage management

Technical Aspects for Integrating Large Scale Renewable Energy

- Security Issues - transmission level
  - Ability to avoid contributing to cascading outages
  - Ability to reduce output if needed to avoid overloaded or insecure power system operation
  - Ability to contribute to voltage and frequency control
  - Ability to contribute to stabilizing system operations following a disturbance
  - Behave in a manner that can be adequately predicted by mathematical models and computer simulations

Technical Aspects for Integrating Large Scale Renewable Energy

- Security Issues - distribution level
  - Ability to contribute to voltage control, while complying with islanding policies
  - Ability to contribute to managing distribution network flows
  - Ability to avoid excessive fault levels
  - Ability to contribute to fault identification and clearance
  - Ability to avoid waveform distortion
  - Behave in a manner that can be adequately predicted by mathematical models and computer simulations

Technical Aspects for Integrating Large Scale Renewable Energy

- Renewable Energy Generation
  - Decentralized and fluctuating input of large amount of Renewable Energy sources
  - Located far from demand centers
  - Need to transmit Renewable Energy power from the sources to the load centers:
    - Long distances
    - Power network
    - New power lines
    - Time limitations

Technical Aspects for Integrating Large Scale Renewable Energy

- Intermittency Characteristics:
  - Based on natural resources
  - Not controllable resources
  - Leads to scheduling accuracy problems
- Overcoming Intermittency by:
  - Larger spinning reserves
  - Regional interconnections
  - Storage technologies
  - Coordinated production and consumption
  - Use of advanced technologies
    - Adequate forecasts, modeling and simulations

Technical Aspects for Integrating Large Scale Renewable Energy

- Control Centers and Smart Grids Role:
  - Renewable Energy forecasts plans
  - Renewable Energy network security
  - Renewable Energy resources real-time monitoring
  - Full integration of weather conditions in network simulations/applications, specially security suites
  - Reserves management and generation control
  - Renewable Energy production scenario simulations
  - Data and display modeling
  - History loggers

Financial Aspects for Integrating Large Scale Renewable Energy

- Policies
  - Consistent policies, regulations and laws
  - Clear rules of ownership, control of facilities, and wheeling issues
  - Effective market policies and tariff structures
- Investments Environment
  - Governmental incentives (taxes, carbon credits, …)
  - Approvals and applications processing
  - Renewable energy funds
  - Emissions credits
- Contractual
  - Dispute resolution processes
  - Power Purchase Agreements (PPA)
  - Financing mechanisms

Financial Aspects for Integrating Large Scale Renewable Energy

- Appraisal & Selection of Renewable Energy Projects
  - Administrative feasibility
  - Technical feasibility
  - Financial capability
  - Marketing appraisal
  - Economic contribution
  - Social objectives
  - Environmental impacts / costs / benefits

Financial Aspects for Integrating Large Scale Renewable Energy

- Investment Risks of Renewable Energy Projects
  - Credit risks
  - Construction and development risks
  - Operating/commercial risks
  - Financial risks
  - Regulatory risks
  - Environmental risks
  - Force majeure

Financial Aspects for Integrating Large Scale Renewable Energy

- Structuring Renewable Energy Projects for Financing
  - Investment proposal
    - Equity
    - Debt
    - Grants
  - Power Purchase Agreement (PPA)
  - Security package
    - Implementation agreement
    - Power Purchase Agreement PPA
    - Land conveyance agreement
    - Ownership structure and agreement
    - Equipment agreement
    - Construction contract
    - Operation and maintenance agreement

Thank you