海上气象学

Offshore meteorology

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概要Summary

海上气象学
Offshore meteorology

- 海上风电前景Offshore prospects
- 海上风流Wind flow offshore
  - 风的分布Wind profile
  - 湍流Turbulence
- 风的数据Wind data
  - 监测Monitoring
  - 数据来源Sources of information
- 风的分析Wind analysis
  - 可行性研究的方法Feasibility study approach
  - 细节分析Detailed analysis
- 发电量预报Energy prediction
- 波浪条件Sea-state conditions
- 其他海上影响Other offshore effects

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海上风电前景
Offshore prospects

- 海上风电的主要市场: Main Markets for offshore
- 英国、丹麦、美国、荷兰、西班牙,中国
  - D, UK, DK, USA, NL, B, S, F, ES, EI, PRC
- **2002年英国贸工部市场调查 :2005 –2007年的发展速度达到每年1 –5GW**
  UK DTI market survey 2002 – development at the rate of 1-5 GW per year for 2005 – 2007
- 通常认为海上风大于陆上风- 仅与海平面平坦地形相比
  It is generally accepted to be windier offshore than onshore – but only when compared to flat terrain at sea level
- **“欧洲海上风电”2004（GH为绿色和平组织的项目）— 海上风电如何满足欧盟30%的需求**
  “Sea Wind Europe” 2004 (GH for Greenpeace) - how 30% of EU demand could be met by offshore wind

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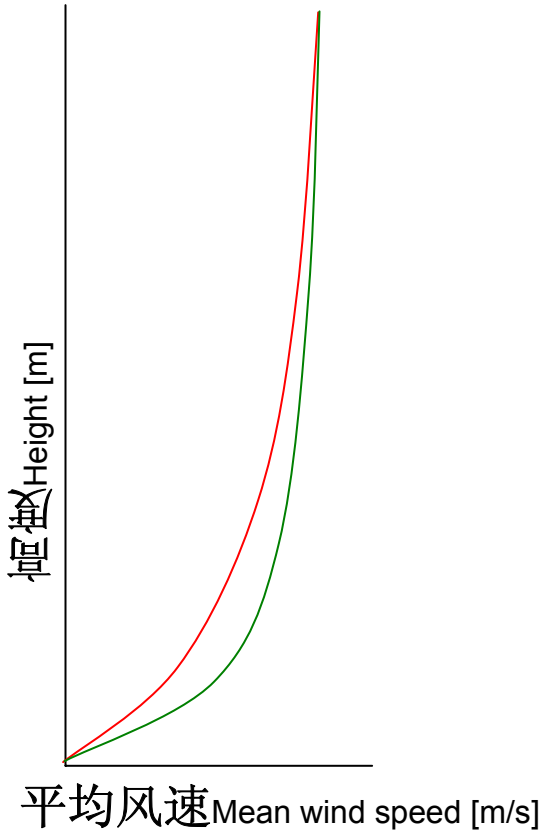
海上风流
Wind flow offshore

基本要素Fundamentals

- 大气层上部（地转自转影响）
  Upper atmosphere (Geostrophic conditions)
- 无阻碍影响Fetch effects
- 地表面粗糙度Surface roughness
  - 低，**0.0001**米－**0.001**米Low, around 0.0001m to 0.001m
    - 低湍流Low turbulence
  - 风速Wind speed and swell dependent
    - 低（风剪切） Low “shear”
- 大气稳定性Atmospheric stability
  - 从海水到空气热传递的度量
    Measure of the heat transfer from the sea to the air
  - 影响气流内部的混合
    Affects the amount of mixing within the flow
  - 影响边界层的形态Also, affects the boundary layer shape
- 不受地形的影响No topographic enhancement



0.03粗糙度 －高风剪切
shear profile for roughness of 0.03 – high shear

0.01粗糙程度－低风剪切
shear profile for roughness of 0.001 – low shear

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海上风数据Wind data offshore

监测选择Monitoring options

- 海上测风杆Offshore mast
  - 低不确定性Low uncertainty
  - 高成本High cost
- 海上浮标Offshore buoy
  - 中等不确定性Moderate uncertainty
  - 成本中等Moderate cost
- 海岸测风杆Coastal mast
  - 高不确定性High uncertainty
  - 低成本Low cost

Picture courtesy Brian Hurley, Airtricity

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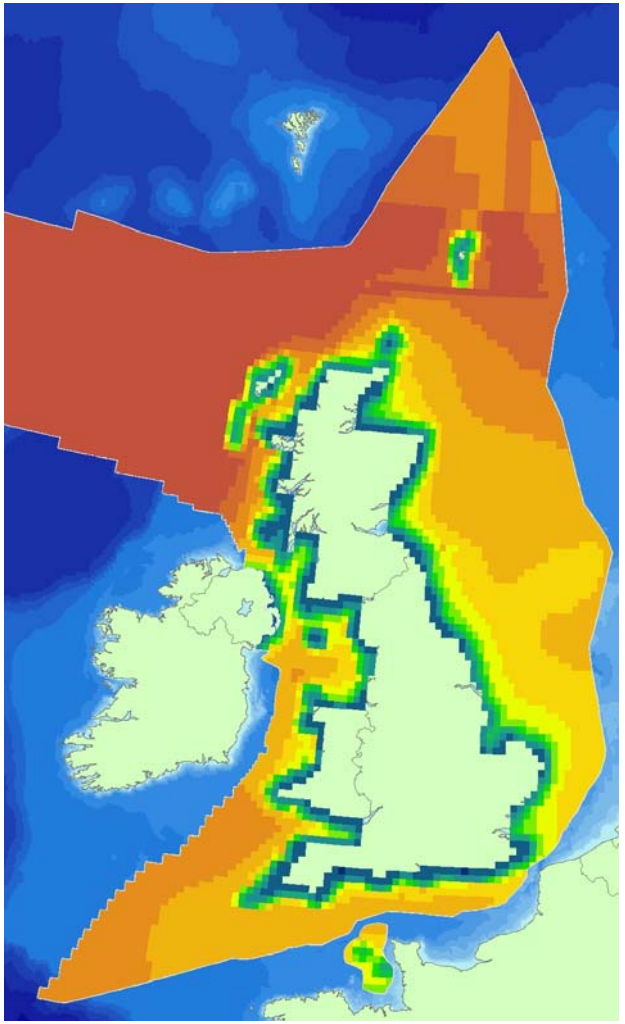
海上风数据Wind data offshore

- 风况分布图Wind maps
  - RISØ
  - GH / GL
  - POWER study
  - RE Atlas
- 海上数据库Offshore databases
  - 气象局MET office
  - **NEXT / NESS**
  - 海岸气象站Coastal MET stations
  - 海上平台Offshore platforms
  - 灯标Light vessels
  - 船舶观测Ship observations
  - 在固定建筑物上的历史测量记录例如:灯塔
    Historical measurements on fixed structures e.g. lighthouses
  - 设计指南Design Guidelines
  - 以前（已发表的）调研Previous (published) reviews
  - 大地观测数据Earth Observation data
  - 再分析/中尺度模型Reanalysis / Mesoscale models



Average annual wind power

RE Atlas, Crown ©2004

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海上风况分析Wind analysis offshore

四阶段方法4 stage approach

阶段 STAGE	描述 DESCRIPTION	数据来源 DATA SOURCES	预测不确定性 PREDICTION UNCERTAINTY
1	场址调查 Site screening	风况分布图，已发表的评估 Wind maps, published estimates	非常高 Very high
2	可行性研究 Feasibility	EO数据，海岸气象站 EO data, coastal met stations	高 High
3	中期评估 Interim assessment	海岸测风杆，现场浮筒 Coastal mast, onsite buoy	中等 Moderate
4	最终评估 Final assessment	现场测风杆 Onsite mast	低 Low

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海上风况分析Wind analysis offshore

阶段4：最终评估 Stage 4： Final assessment

- **MCP**（测量-相关性分析-预测）与岸上风电场类似
  MCP (Measure-Correlate-Predict) as onshore
  - 通过现场测量的数据和参考气象站相关性数据分析进行海上风况预测
    Prediction of wind data offshore by correlation between site measurement and reference station

- 需要注意：
  Attention to:
  - 发现和量化安装的影响
    Identifying and quantifying mounting effects
  - 边界层建模
    Boundary layer modelling

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发电量预测Energy prediction

与岸上风电场类似，但是要注意

As onshore primarily, but

- 受地形的影响很小
  Minimal topographic effects
- 尾流损失可能更高
  Wake losses likely to be higher
  - 较低湍流导致尾流恢复缓慢
    Lower turbulence results in slower wake recovery
  - 更大的风电场
    Larger wind farms
  - 有可能增加间距
    Although there may be more scope to increase spacing
- 可利用率的计算更加复杂
  Availability much more complex

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海况条件Sea-state conditions

- 一般条件：
  Normal conditions:
  - 浪高、周期和风速分布（**Hs**、**Tz**及风速散点图）
    Distributions of wave height, period & wind speed (scatter diagram of Hs, Tz, and wind speed)
  - 风和浪方向的分布图
    Distribution of wind-wave misalignment
  - 波浪能量谱
    Wave energy spectrum
  - 潮汐范围
    Tidal range
  - 海流的速度和方向
    Current velocity and direction

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海况条件Sea-state conditions

- 极限载荷条件：

  Extreme conditions:

  - 极限谱值：H_{s1} / T_{z1}，H_{s50} / T_{z50}

    Extreme spectral values: H_{s1} / T_{z1}, H_{s50} / T_{z50}
  - 极限浪高、周期、方向及类型

    Extreme wave height, period, direction & type
  - 极限潮汐高度加上暴风雨

    Storm surge plus extreme tidal height
  - 极限海流

    Extreme currents
  - 冰载Ice

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其他海上影响Other offshore effects

- 潮汐的影响
  Tidal effects
  - 边界层上下移动
    Vertical shift of the boundary layer
  - 应该获得详细数据（**MSL**发电量预测）
    Clear datum should be defined (MSL for energy prediction)
- 低层喷射
  Low level jets
- 风浪相互影响
  Wind-wave interactions

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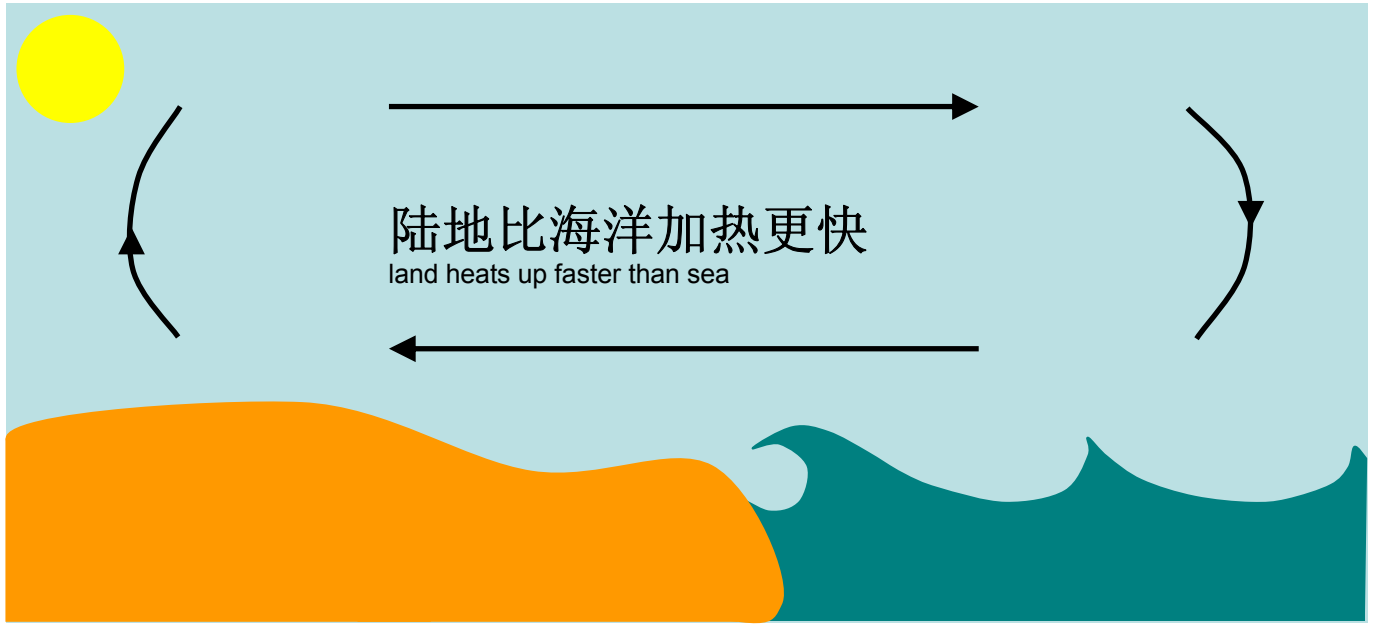
其他海上影响Other offshore effects

海陆风Sea Breezes

- 什么是海陆风
  What is a sea breeze?



- 主要在低风时发生
  Mainly a low wind phenomenon

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回顾Recap

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