Climate, Climate Change Nuclear Power and the Alternatives

Lecture 8
Climate Change and Wind Energy
[Based in part on PhD work of Paul Nolan]
Supervisor: Peter Lynch

Overview
- Temperatures in Ireland have mirrored this global trend
- Changes in the wind climatology are expected
- New increased target of 40% of electricity from renewable resources by 2020
- It is vital to model the impact of climate change on future wind patterns over Ireland.

Wind Energy – the next 50 years
- 50 year world outlook: context population stabilized or declining, oil and gas running out, coal restricted, nuclear?
- Nearer term oil limited to transport sector
- Global energy demand and resources of renewables available.
### Per Capita Electricity Consumption

<table>
<thead>
<tr>
<th>Country</th>
<th>Consumption (kWh/person/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>14,000</td>
</tr>
<tr>
<td>W Europe</td>
<td>2,000</td>
</tr>
<tr>
<td>China</td>
<td>8,000</td>
</tr>
<tr>
<td>India</td>
<td>4,000</td>
</tr>
</tbody>
</table>

### Carbon Emissions per Capita, Top Ten Emitting Nations, 1996

- USA: 6.0 Tons Carbon per Person
- Canada: 3.0 Tons Carbon per Person
- Germany: 2.0 Tons Carbon per Person
- Russia: 1.6 Tons Carbon per Person
- U.K.: 1.2 Tons Carbon per Person
- Japan: 1.0 Tons Carbon per Person
- S. Korea: 1.0 Tons Carbon per Person
- Italy: 0.9 Tons Carbon per Person
- China: 0.8 Tons Carbon per Person
- India: 0.7 Tons Carbon per Person

Compiled by Worldwatch Institute

### ESTIMATED LAND WIND RESOURCES

The world’s wind resources are about 53,000 TWh/year.

- Australia: 3,000
- North America: 14,000
- Latin America: 5,400
- Western Europe: 4,800
- Eastern Europe and former Soviet Union: 10,600
- Rest of Asia: 4,600
- Africa: 10,600

Ref: Windforce 12 Greenpeace
Source: Wind resources from Michael Grubb and Niels Meyer, 1994
Typical wind field over Europe

European average wind power generation between 1965 and 1998, over 60 well-distributed sites

Typical 24 hour Forecast

The Wind Supergrid

Wind versus Nuclear Costs

Wind On land:
Range: 30 euro\(^2\) to 80 euro\(^2\) per MWh

Wind Offshore:
Range: 90 euro\(^2\) to 110 euro\(^2\) per MWh

Nuclear
43 euro\(^2\) and 54.3 euro\(^2\) per MWh

Stann Review: 58 to 52 euro
Sustainable Development Commission, UK: 33.9 to 51.6 euro

Modelling the Winds

The impact of greenhouse gases on climate change can be simulated using Global Climate Models
The typical resolution of Global models is 50km or greater

We are using a Regional Climate Model (RCM) to dynamically downscale the coarse information from the global models.

References
1. Stann Review
2. G.Giebel
3. Current North Sea
4. UK Energy Review 2006 Nuclear Cost Benefit
5. UK Energy Review Synthesis of Cost Benefit Analysis

Range 30 euro to 110 euro per MWh
1 0 July 2006

1 2

Global Model to Regional Model
The IPCC Greenhouse Gas Emission Scenarios

The CLM 7km simulations were run on the 'Stokes' Linux cluster at the Irish Centre for High-End Computing (ICHEC). Each compute node has two Intel Xeon E5462 quad-core processors and 16GB of RAM. See http://www.ichec.ie

CLM Setup

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- Each compute node has two Intel Xeon E5462 quad-core processors and 16GB of RAM.
- See http://www.ichec.ie

Validation of the CLM Regional Climate Model

- The CLM was validated by performing a 29-year climate simulation (1981-2000).
- ERA-40 and ECHAM5 boundary data were used.
- We compared the results with observations and ERA-40 data.

Weibull Distribution

- At each grid point \((i,j)\) we fit a Weibull distribution

\[
W(x) = \frac{\beta}{\alpha} x^{\alpha-1} e^{-(x/\beta)^\alpha}
\]

for \(x \in (0, \infty), \alpha, \beta > 0\)

CLM Validation at Casement Station (1981-2000)
**Observed Wind Rose at Casement Station (1981-2000)**

**Location of Casement Station**

**CLM Validation at Casement Station (1981-2000)**

**RCA Future Climate Projections 2021-2060**

**CLM Future Climate Projections**

**Winter A1B Scenario (2021 – 2060)**

**Winter (A1B, A2, B1 & B2) Scenarios**
The method of Regional Climate Modelling was used to simulate the wind climatology of Ireland at high spatial resolution. The models were validated by performing past simulations of the Irish climate and comparing the results to observations. Projections for the future Irish climate were generated by downscaling for a reference period 1961-2000 and future period 2021-2060. Results show an overall increase in mean wind speeds for the future winter months and a decrease during the summer months. The projected changes for summer and winter were found to be statistically significant over most of Ireland.