The Arago Insulated Cross Arm

Unlocking transmission capacity

THE CONCEPT
LAB TESTING
MANUFACTURING
OUTDOOR TRIALS
• Joint Venture: University of Manchester EPL Composite Solutions Ltd
  – Locations: Manchester and Loughborough
  – Owns IPR and commercialising the technology
  – Initial funding round complete
• Over £2.8 Million invested over past 6 years
  – Including £2 Million from NG and SSE
• Collaboration with 3 end users:
  – National Grid, SSE and Eirgrid
Power grid can’t cope when the wind blows

Tim Webb

The amount of potential electricity from onshore wind farms that has been allowed to go untapped has more than doubled this year because the grid cannot cope.

Developers have received payments of £19 million not to generate 215 gigawatt hours — enough electricity to supply nearly 50,000 households for a year.

This is equivalent to three 30-megawatt wind farms, costing about £90 million to build, standing idle since the beginning of the year. Last year wind farms were paid not to generate 103GWh.

National Grid makes the payments in return for electricity, mostly when it is very windy and there is low demand. The payments are recouped by charges on consumers’ electricity bills.

The company blamed very windy weather over the summer for the large amount of potential electricity going to waste. Last weekend alone, £3.9 million was paid to wind farms not to generate.

However, the amount per MWh that wind farms were paid not to generate has fallen significantly. National Grid has tightened rules to reduce the windfall profits that developers can make from these payments after an outcry from consumer groups.

The average payment they receive in addition to the wholesale price of electricity (about £50 per MWh) this year is £89 per MWh, compared with £130 last year and £218 in 2011.

John Constable, director of the Renewable Energy Foundation, a think-tank that is critical of the cost of wind farms, said: “National Grid is struggling to deal with this problem at reasonable cost to the consumer, and clearly needs some help from [the industry regulator] Ofgem.”
Industrial Requirements

• Need to increase power transmission globally
  – Increase in connection of Renewable Power
    • UK to add 43 GW by 2020
  – Increasing Load Growth with Developing Economies
  – Increased Use of Electricity for Energy

• Reduced **time** and cost to introduce capacity
  – Obtaining routes and planning permission for new lines
    • A two-year delay can add system costs equivalent to many times the cost of the line
  – New capacity at minimum cost
  – Maximising use of existing capital assets
Patented Electrically Resistant Composite Profile

Outer Coating
- Electrically insulating
- Weather proof
- Low Surface Energy
- Shaped to avoid Contaminant build up
- Low moisture absorption

Central Composite Core
- Provides further electrical resistance
- Structural composite centre
- Void free laminate
New Build: save time and money

• Dramatic reduction in pylon height
  – 275kV: 22%
  – 400kV: 26%
• Cost savings through:
  – Reduced time in the planning process
  – Smaller pylon structures
  – Reduced foundations
Increased clearance

- At key points in network to overcome sag and allow increased currents
- Low points or new transport routes
- Raise height of conductors by 3 to 4 metres
TESTING
Silicone Electrical Tracking Testing
Sample Failure Times

- Off the shelf Pultrusion                     35 Mins
- Enhanced Composite Material                5 Hours
- Silicone coated Insulated Composite        8 Hours
- Typical Silicone rubber insulator          10 Hours
Lab scale testing

Testing
- Penetrative dye testing
- Boiling for 42 hours
- 5 sudden load releases
- Cycling from -30 to +50°C under mechanical load
- End fitting pull off
- Load – time testing
- Various electrical tests

Mechanical Testing

High Voltage Testing

Die Penetration Testing
Load release testing was performed using a re-fitted version of a pre existing test rig

- All 3 samples tested simultaneously
- Linkage coupled using a pin intended to break at 60kN
- Load slowly increased until pin broke
- Process performed 5 times (as required)

<table>
<thead>
<tr>
<th>Test</th>
<th>Load which was suddenly released [kN]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>75.07</td>
</tr>
<tr>
<td>2</td>
<td>82.20</td>
</tr>
<tr>
<td>3</td>
<td>83.13</td>
</tr>
<tr>
<td>4</td>
<td>81.01</td>
</tr>
<tr>
<td>5</td>
<td>Not recorded</td>
</tr>
</tbody>
</table>
Compression testing

- Pultruded compression member subjected to axial compression in similar manner to Lecht profiles
- No failure with axial load of 170kN (L3 normal loading 131kN)
• Electrical testing to Phase to phase 400kV
• Silicone breakdown after wet switching impulse trials
• Mechanical buckling validation on profile with small rig to 185kN
• Full scale mechanical testing deflection limited due to nose design limitations (approx. 106kN)
• Small scale salt fog trials suggest noticeable effect of surface run off angle on durability
Long term live trial of Arago cross arms:

- Installed in a coastal location in NE Scotland, energised at 400kV
- Exposed to coastal, salt fog pollution
- Valuable for developing installation procedure, conductor access methods and cross checking lab testing / computer modelling
- Current leakage, weather and images are being recorded for analysis in Manchester

View of St Fergus site

Weather Data

Electrical Data
MANUFACTURING
Compression Cross Arm
Key Manufacturing Components

- Pultrusion of GRP core
- Moulding and mounting of sheds
- Cast End Fittings
One of Hübers’ injection moulding machines was used to mould the silicone over the core with a modular mould machined from an Aluminium alloy.
Manufacturing – Summary

- Pultruded core
- Cast End fittings / Grading Ring
- Liquid Silicone Over Moulding

- Pultrusion Equipment
- Sand Mould
- Member in Mould

- Cast Grading Ring

- First Completed Member
An operational installation
Field trials

• Following rigorous testing three field trials have been conducted starting in 2010 through 2013 in partnership with:
  – Scottish Hydro Electric Transmission Ltd
  – National Grid
  – NorPower
• ...and are still on-going in 132kV and 400kV live operational installations.
• These trial sites are in difficult environmental conditions in Scotland.
• Yielding valuable data and most importantly affirming a clear and growing TSO / DNO demand for Arago technology
Arago Insulator Cross Arms at Decommissioned Section of 132kV Line Retrofitted on PL16 Towers at Lecht, Scotland, SSE, November 2010
Key Benefits

• Major savings in time and cost associated with the planning process
  – Cost of constraints
  – Renewables connected to market faster
  – Less materials and lower installation costs

• Increased return on existing lines
  – Up to double the power (voltage and current upgrades)
  – Alternative to new lines or (expensive) undergrounding
  – Can avoid/postpone new routes and associated planning time and cost
“This innovative technology has the potential to deliver a cost effective way of increasing the power carried on our transmission network.”

David Gardner, Director of Transmission, Scottish Hydro Electric Transmission

“This innovation should lead the way to the first major improvement in line configuration for decades and is world leading in concept.”

Nick Winser Executive Director, National Grid

• Winner of the IET Power and Energy Award 2012
• Winner of Energy Innovation Centre’s “Existing Performance Improvement” 2010