Current Industry Status – Market Size

- National target of 1,800 MW wind power by 2022
- Three commercial wind farms now operating
  - West Huaybong 2/3: Adjacent 2 x 103.5 MW, Korat
    - Developed by Wind Energy Holding
    - Siemens 2.3 MW x 90, 103 m blades, 100 m hub height
  - Theppana: 7.5 MW, Chaiyaphum
    - Developed by EGCO
    - Goldwind 2.5 MW x 3, 108 m blades, 90 m hub height
- Active project pipeline of >1,600 MW
  - Portfolios of 3-6 windfarms from 4 major developers
Current Industry Status – Incentives

• Tariffs in Thailand of 6.1 THB/kWh (~19 US¢/kWh)
  – Comprises THB 3.5 “adder” tariff over 10-years plus average time-of-use tariff (peak and off-peak rates)
  – International feed-in tariffs typically 10-13 US¢/kWh, for 15-20 years
  – Favourable; reflecting higher costs and lower wind speeds
  – THB 1.5 additional “adder” tariff for displacing diesel, in off-grid projects, or in Southern 3 provinces

• Tax incentives
  – Corporate tax exemptions
  – Import duty relief on equipment
Current Industry Status – Wind Resource

• Capacity factors in Thailand of 20-30%
  – Considering sites with wind speeds of 5 - 7 m/s
  – Resource concentrated in North-East and Peninsular areas

• 20% one-year uncertainty not unusual in Thailand
  – Limitations in long-term wind data (mesoscale correlation)
  – Wind shear extrapolation to ever-higher hub heights
  – Lack of accurate terrain data prior to construction-phase surveying

• Strong monsoonal and diurnal production patterns
  – Yield highest at night-time, with high wind shear
Seasonal Wind Resource Variation

Seasonal Energy Output

% of annual energy yield

Month
Annual Average Diurnal Wind Shear

![Annual Average Diurnal Wind Shear Graph]

- Graph shows the annual average diurnal wind shear over the course of a day.
- The y-axis represents the wind shear exponent, ranging from 0 to 0.4.
- The x-axis represents the hour of the day, ranging from 0 to 24.
- The graph indicates a peak in wind shear in the early morning and late evening, with a trough around midday.
Current Industry Status – Turbine Technology

• Wind turbine suppliers
  – Goldwind, GE, United Power, Vestas – recently among most active 4 suppliers for new potential wind farms

• Wind turbine characteristics for new projects
  – Geared and direct-drive both being widely considered
  – Blade length increasing to 120 m and above
  – Hub height increasing to 120 m and above
    • Hybrid concrete/steel tubular towers
    • Space frame towers
  – Cranes used for installation so far narrow-track crawler cranes; wheeled cranes and tower cranes also proposed
Current Industry Status – Project Development

• Higher hub heights are cost-effective but lead to higher project costs than internationally
  – Disproportionally higher tower costs
  – Approaching capacity limits of available cranes
• Financing mostly by domestic Lenders
  – Lender preference for an EPC contractual wrap
  – Meeting debt-service cover threshold at P90 can be tough
• Long project development times
  – Optimal use of newer turbine models
  – Optimal contracting arrangement
Summary of Challenges

• Moderate wind speeds; higher uncertainty in yield
  – Even with good EYA modelling input data; inherent constraint
• Highly specialist skills; in planning, construction and O&M
• Minimum scale economies
• Community buy-in
• Development of clear and appropriate regulation
• Interconnection risks
<table>
<thead>
<tr>
<th>Challenges – Highly specialist skills</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase:</strong></td>
</tr>
<tr>
<td>Wind energy yield analysis</td>
</tr>
<tr>
<td>Managing interfaces and commercial terms with turbine manufacturers</td>
</tr>
<tr>
<td>Heavy crane logistics (imported?)</td>
</tr>
<tr>
<td>Turbine transportation</td>
</tr>
<tr>
<td>Turbine foundation design / construction</td>
</tr>
<tr>
<td>Managing grid operator requirements and interconnection/offtake risk</td>
</tr>
<tr>
<td>Community management</td>
</tr>
</tbody>
</table>
Challenges – Minimum scale economies

- VSPP and smaller SPP scale wind projects face scale economy challenges
  - Broad skill base to develop/construct; costly
  - Financing not yet a smooth process; costly
  - No ability to smooth fixed maintenance costs across broader revenue base; including spares holding, skilled technicians, heavy crane reserve
Challenges – Community buy-in

• Upfront engagement key
• Explanation of technology
  – Visit existing wind farms
  – Detail construction impacts and mitigations
  – Detail benefits to the community
• Grievance mechanism for construction period
  – Address issues such as road damage, other access blockages, dust, crop damage etc
• Community support funds
Challenges – Clear, appropriate regulation

• Land rights a barrier
  – Many promising wind farm sites in agriculturally designated land (Sor-Por-Kor) or national forest land
  – Limitation on number of available turbine footprints, for land type (50 rai lease limits); setback limits TBC
  – Long term leases assignable to Lenders?

• Watershed issues
  – Historical classifications?
  – EIA for transmission line?
Challenges – Clear, appropriate regulation

• Code of Practice issued outlining required studies
• Noise
  – Regulatory limits not strict
  – No limits on tonal noise
  – But still need to be a good neighbour...
• Visual Impact, shadow flicker
• Telecommunications and radar interference
  – No clear regulatory framework
Challenges – Interconnection risks

• Wind farms exporting to EGAT via PEA network face inconsistent grid code requirements (e.g. LVRT)
• Lack of clarity on “priority dispatch” terms for renewable generators;
  – No compensation in the event of grid outage
  – Limited information on load-flow or network upgrades
• Grid operator (EGAT/PEA) standards for inverter based generators still evolving
  – Solar grid-tied inverter rules currently being applied; not standard for wind and testing can be impractical
Round up

• Thailand’s wind power industry is active, but current challenges create drag on development timescales:
  – Accurate site data and skills to assess feasibility
  – Appropriate regulation
  – Comfort from stakeholders (community, lender...)
  – Sourcing skills to manage construction risk; risk allocation
  – Meeting Lender financial performance thresholds

• Personally optimistic that wind developments will pick up pace as experience improves
  – Further regulatory progress needed in parallel