Cold climate wind market study 2020-2025

Winterwind 2020
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IEA Wind Task 19
VTT Technical Research centre of Finland Ltd.
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Introduction

- Timo Karlsson
- Decade+ with wind
- With VTT since 2012
- Cold climate issues mainly
- Operating agent of IEA Wind TCP task 19
IEA Wind TCP Task 19 – Wind Energy in Cold climates

Mission:
   Improve large scale deployment of cold climate wind power in a safe and economically feasible manner

Method:
   Gathering and disseminating information and research regarding wind energy in cold climates

International collaborative platform

Established under IEA (international energy agency)

Members from 10 Countries
Cold climate wind market

Questions:

- How large is cold climate wind market?
- Where is it?
- How is it growing?
Cold climate wind

Cold Climate (CC)

Instrumental icing during more than 1% of the year
Meteorological icing during more than 0.5% of the year

Icing Climate (IC)

(LTC)
Low Temperature Climate

Air temperature < -20°C on more than 9 days per year
Average annual air temperature < 0°C

## IEA Ice Classification

<table>
<thead>
<tr>
<th>IEA Ice Class</th>
<th>Duration of Meteorological Icing [% of Year]</th>
<th>Duration of Instrumental Icing [% of Year]</th>
<th>Production Loss [% of AEP]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>&gt;10</td>
<td>&gt;20</td>
<td>&gt;20</td>
</tr>
<tr>
<td>4</td>
<td>5-10</td>
<td>10-30</td>
<td>10-25</td>
</tr>
<tr>
<td>3</td>
<td>3-5</td>
<td>6-15</td>
<td>3-12</td>
</tr>
<tr>
<td>2</td>
<td>0.5-3</td>
<td>1-9</td>
<td>0.5-5</td>
</tr>
<tr>
<td>1</td>
<td>0-0.5</td>
<td>&lt;1.5</td>
<td>0-0.5</td>
</tr>
</tbody>
</table>

¹: IEA Wind Recommended Practices for wind energy projects in cold climates edition 2011
Method

- Establish the current size of cold climate market
  - Use turbine databases and meteorological icing information
- Icing information from VTT Wiceatlas
- Combine the current estimate of the cold climate market with general wind market size growth estimates
- Use multiple data sources when possible
VTT World Icing atlas

- Global database of meteorological icing
- Based on weather observations
- Contains information on both icing and cold climate conditions
- Wind Power Icing Atlas – WIceAtlas (vtt.fi)
Data sources

Turbine data
- http://www.thewindpower.net
  - Commercial database, global
- Open power system data project
  - (https://open-power-systems-data.org)
- WRI World power plant database
- Natural Resources Canada
- USGS wind turbine database

Market forecasts
- GWEC
- Windeurope
- Canada energy regulator
Current cold climate market

- Size of cold climate market is roughly ~22 +- 2% globally
- Global onshore wind capacity in 2020 is ~700 GW (GWEC 2021)
- Size of cold climate market ~156 GW
  - 137 GW icing
  - 67 GW Low temperature
Current market

Icing Climate Total
- Asia: 6.7 GW (6%)
- Europe: 39.2 GW (33%)
- North America: 72.7 GW (61%)

Low Temperature total 2020
- Asia: 38.5 GW (52%)
- Europe: 4.0 GW (5%)
- North America: 31.5 GW (43%)
Cross-category overlap

- Some sites are both low temperature and icing, some are one but not the other
- In Asia, cold, dry climates common
- In Europe and North America all low temperature sites are all icing sites

<table>
<thead>
<tr>
<th>Region</th>
<th>Icing</th>
<th>Low temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>75.6%</td>
<td>22.6%</td>
</tr>
<tr>
<td>YES</td>
<td>0.0%</td>
<td>1.8%</td>
</tr>
<tr>
<td>North America</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>70.4%</td>
<td>17.6%</td>
</tr>
<tr>
<td>YES</td>
<td>0.7%</td>
<td>11.3%</td>
</tr>
<tr>
<td>Asia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO</td>
<td>87.1%</td>
<td>1.3%</td>
</tr>
<tr>
<td>YES</td>
<td>11.3%</td>
<td>0.2%</td>
</tr>
</tbody>
</table>
Previous efforts

- Similar analysis has been done by task 19 twice now
- 2012
  - published in BTM world market update 2012
  - Presented in winterwind 2014
- 2016
  - Presented in winterwind 2017
2016 estimate

<table>
<thead>
<tr>
<th>Cumulative installed capacity by end of 2015 [MW]</th>
<th>Forecasted capacity by end of 2020 [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low temperature</td>
<td>Icing*</td>
</tr>
<tr>
<td>40 500</td>
<td>86 500</td>
</tr>
<tr>
<td></td>
<td>Low temperature</td>
</tr>
<tr>
<td>62 500</td>
<td>Icing*</td>
</tr>
<tr>
<td></td>
<td>123 000</td>
</tr>
<tr>
<td><strong>Total 127 000</strong></td>
<td><strong>Total 185 500</strong></td>
</tr>
</tbody>
</table>

*: IEA Ice Classification ≥ 2 meaning > 44h/a of meteorological (in-cloud) icing

+12GW/a -> 59GW of new installations to cold climates by 2020!
➢ Compare: new offshore +4GW/a -> 20GW by 2020

http://www.windpowermonthly.com/article/1403504/emerging-cold
2016 estimate

- The 2016 forecast overshoots the current market size estimate
- Updates to the icing database
- Better estimation of the overlap
- Source forecast overestimates the growth that happened
  - Total market size in the forecast was bigger than actual in 2020
Forecast 2020-2025

Cold Climate wind total

<table>
<thead>
<tr>
<th>Year</th>
<th>GW</th>
<th>Asia</th>
<th>North America</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td></td>
<td>43.6</td>
<td>73.5</td>
<td>39.2</td>
</tr>
<tr>
<td>2021</td>
<td></td>
<td>48.2</td>
<td>81.1</td>
<td>41.5</td>
</tr>
<tr>
<td>2022</td>
<td></td>
<td>53.3</td>
<td>85.7</td>
<td>43.4</td>
</tr>
<tr>
<td>2023</td>
<td></td>
<td>58.9</td>
<td>89.1</td>
<td>46.2</td>
</tr>
<tr>
<td>2024</td>
<td></td>
<td>64.9</td>
<td>94.6</td>
<td>48.9</td>
</tr>
<tr>
<td>2025</td>
<td></td>
<td>71.3</td>
<td>100.3</td>
<td>52.0</td>
</tr>
</tbody>
</table>
## Forecast 2020-2025

<table>
<thead>
<tr>
<th>Estimated cold climate wind market size in GW in 2020</th>
<th>Forecast for Cold climate wind market in GW for 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Icing climate</strong></td>
<td><strong>Low temperature</strong></td>
</tr>
<tr>
<td>118.6</td>
<td>74.0</td>
</tr>
<tr>
<td><strong>Total 156.2</strong></td>
<td></td>
</tr>
</tbody>
</table>

Growth estimates assume that the local share of cold climate remains similar through the forecast period.

<table>
<thead>
<tr>
<th>Year-over-year growth, average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Icing climate</strong></td>
</tr>
<tr>
<td><strong>Low Temperature</strong></td>
</tr>
<tr>
<td><strong>Cold Climate total</strong></td>
</tr>
</tbody>
</table>
Forecast 2020-2025

North America

Europe

Asia

<table>
<thead>
<tr>
<th>Region</th>
<th>Icing 2020</th>
<th>Icing 2025</th>
<th>Low temperature 2020</th>
<th>Low temperature 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>72.7</td>
<td>99.3</td>
<td>31.5</td>
<td>43.0</td>
</tr>
<tr>
<td>Europe</td>
<td>39.2</td>
<td>52.0</td>
<td>4.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Asia</td>
<td></td>
<td></td>
<td>6.7</td>
<td>11.0</td>
</tr>
</tbody>
</table>

Icing

Low temperature
Conclusions

- Cold climate is the largest "special" wind power market today
- 20 %, Onshore
- Majority of cold climate sites are in ice class 2
- Mild overlap between low temperature and icing
- Europe, North America majority of the icing market
References

- Wind power plant database: https://www.thewindpower.net/
- Global Wind Energy Council: GWEC global wind report 2021
- VTT Wind Energy Icing Atlas
- Canadian Wind Turbine Database
- The U.S. Wind Turbine Database
  - https://eerscmap.usgs.gov/uswtdb/