TALL WIND TURBINE TOWERS: THE CHALLENGES

Wind turbine hub height: evolution since 2000

Wind Turbine Tower Height

- Belgium
- France
- Germany
- Netherlands

Hub height (m)


0 20 40 60 80 100 120 140
Wind turbines are taller and taller for the following reasons:

- More wind at higher height (wind shear).
- A bigger rotor needs more clearance from the ground (unless you want to chop trees...).
- In industrial areas or forests, being away from obstacles is better (less turbulence, more steady wind conditions).

Tall wind turbine towers; the challenges

Turbine Cost (incl. foundation) vs. Energy Yield
Reach for the sky

- First tall tower: Fuhrlander 2.5MW at 160m hub height (90m rotor diameter, blade tip 205m).
- 75% of capacity installed in Belgium in 2013 is above (or equal to) 100m.
- 70% of capacity installed in France in 2013 is above (or equal to) 100m.
- 5% of capacity installed in the US in 2013 is above 100m.

Wind turbine tower categories

**Tubular steel tower**

- Maximum bottom section diameter of 4.1 - 4.3m (for transport).
- For height above 120m, tower thickness too big to be competitive.
- Max height of 100-120m.
- Traditional design (120m, 2MW, 300T).
Wind turbine tower categories

**Concrete tower**
- Pre-cast concrete sections.
- Alstom ECO 122: 199m hub height!
- Acciona AW116/300: 50% sales with concrete towers.
- Hybrid towers: more popular
- 138m, 2.3MW, 1900T (full concrete), 1500T (Hybrid: 22 concrete sections +3 steel sections).

Wind turbine tower categories

**Lattice steel tower**
- Initially 4 legs but problems with birds and corrosion (1990’s, California & Spain)
- Now 5 leg design with plastic fabric to protect equipment and lift (GE 2.75MW, 139m hub height)
- 20-30% less steel than tubular steel tower
- But huge footprint (very wide base) -> potential issues in industrial areas
Wind turbine tower categories

**Tubular steel tower**
- Wooden used in older wind turbine blades (up to 30-35m long).
- Laminated panels used.
- Cheap solution (1.2€/kg).
- Vensys 1.5MW prototype with wooden tower.
- 138m, 1.5MW, 200T.

![Image of a wind turbine tower](image)

Wind turbine tower costs

**Tower alternatives for a 3MW turbine**
(average wind speed of 6.2m/s at 100m height)

![Graph showing tower costs](graph)
Wind turbine tall tower: the challenges

- Height restrictions: aviation rules drive total blade tip height.
- Transport: concrete tower sections easy to transport. Not always the case for steel tower sections.
- Concrete tends to be cheaper than steel (Brazil case) but pre-casting concrete facility locally is needed (shipping from Europe is expensive).
- Tall tower allows to capture higher and less turbulent wind, therefore better energy yield and less fatigue loads, but no track record yet.

Tall tower: the impact for project finance

Impact of tall turbines on project risks are mainly:

- Energy yield assessment: wind data at 120m+ is not usually available and wind flow models will have to be adjusted.
- Certification issues: turbines with tall towers are not necessarily fully certified yet.
Impact for energy yield assessment (1/7)

Energy yield assessment methodology (with met mast)

1. Met data processing.
2. Long term extrapolation.
3. Horizontal & vertical extrapolation.
4. Loss calculation (P50).
5. Uncertainty assessment (P75/P90).

Impact for energy yield assessment (2/7)

Energy yield assessment methodology (without met mast)

Use of Merra points over Belgium (not European Wind Atlas)

Interpolation of wind statistics at the 4 nearest Merra points around project
Impact for energy yield assessment (3/7)

The P50 is derived from the gross energy yield by taking into account losses. An uncertainty analysis is performed to assess the P75 and P90:

<table>
<thead>
<tr>
<th>Source</th>
<th>[%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-term wind regime</td>
<td>2.0</td>
</tr>
<tr>
<td>Long-term extrapolation</td>
<td>0.8</td>
</tr>
<tr>
<td>Climate variability (20 years)</td>
<td>2.1</td>
</tr>
<tr>
<td>Wind shear modelling</td>
<td>0.7</td>
</tr>
<tr>
<td>Forest effects</td>
<td>0.9</td>
</tr>
<tr>
<td>Micro-meteorol</td>
<td>0.3</td>
</tr>
<tr>
<td>Other production losses</td>
<td>1.3</td>
</tr>
<tr>
<td>Combined uncertainty (20 years)</td>
<td>11.0</td>
</tr>
</tbody>
</table>

Impact for energy yield assessment (4/7)

When a met mast is used, the uncertainty over vertical extrapolation can be reduced either by:

- Installing a taller met mast: expensive and hub height is never known when development starts.
- Wind shear at high height less sensitive to roughness.
- Lidar is a very good option to investigate heights above 100-120m+.
Lidar for better wind profile assessment (5/7)

Lidar used to fill up gaps between mast height (80-100m) and turbine hub height (140m+):
- Fine tuning WaSP windflow model.
- Decreasing vertical extrapolation uncertainty (3 months measurement only).

<table>
<thead>
<tr>
<th>Vertical extrapolation error as a function of Lidar measurement duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site 1</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Site 2</td>
</tr>
<tr>
<td>Site 3</td>
</tr>
<tr>
<td>Site 4</td>
</tr>
<tr>
<td>Site 5</td>
</tr>
<tr>
<td>Site 6</td>
</tr>
</tbody>
</table>

Impact for energy yield assessment (6/7)

- When no met mast is used, the uncertainty over vertical extrapolation cannot be reduced.
- More operational data (from existing tall wind turbines) is required to fine tune the MERRA-based model.
- As a consequence, vertical extrapolation uncertainties will remain high (1.5-2% instead of 0.4%).
Impact for energy yield assessment (7/7): Conclusions

- When a mast is used, uncertainties can be lowered, and therefore P90 can be increased, by using Lidar: 3 months of measurement are enough.
- When no mast is used, uncertainties cannot be lowered and are increased as no operational data for tall wind turbines exists in Belgium yet.

Impact for Certification (1/7)

What is Certification?

- Proof that design, production, testing are done in accordance with internationally accepted guidelines (IEC 61400).
- Allows for international standardisations → Export.
- Legal obligation e.g. in Flanders, Wallonia.
- Independent check: done by an accredited third party e.g. TÜV, Bureau Veritas, DNV-GL,... → Certificate
- Quality approval which is important to investors/financiers.
**Impact for Certification (2/7)**

**What is Type Certificate?**

- Different types of certification:
  - Turbine certification
  - Project certification
  - Foundation certification
  - Component certification

- Type Certificate = Applicable to a series of wind turbines of common design and manufacture.

**Type Certificate means:**

- Confirmation that a wind turbine type is designed, documented and manufactured in conformity with design assumptions, specific standards and other technical requirements.

- Issued in accordance to different standards and systems e.g. IEC type certificate system, Danish type certification system, Dutch type certification system.
Existing turbines are being offered, for specific hub heights, without full Type Certification, sometimes even without Design Approval (Design Approval or Statement of Compliance).
Impact for Certification (4/7)

Mitigations strategies are:

- Design life statement (in any case).
- Type Certificate before Financial Close (as Condition Precedent).
- If no Type Certificate available, Design Approval at Financial Close and Type Certificate at project completion (last payment milestone).
- If no Type Certificate or no Design Approval available at Financial Close, customized payment milestone (with delays LD if Design Approval not delivered timely).

Impact for Certification (5/7)

Case study 1

- Wind project with new hub height (turbine already certified but not at this height).
- No Design Approval available before FC.
- Solution:
  † Type approval to be delivered before turbine erection.
  † Compensation mechanism in place if delivery of the certificate (Liquidated Damages) by turbine supplier is delayed.
**Impact for certification (6/7)**

**Case study 2**

- Wind project with new hub height (turbine already certified but not at this height).
- No Design Approval available before FC.
- Solution: Financial Close not issued before Design Approval issuance.

**Impact for certification (7/7) - Conclusions**

Potential certification impacts of tall towers are:

- Non compliance with regulation (Vlarem), causing delays in construction.
- Potential issues with insurances.
Tall wind turbine towers; the challenges

**Tall wind turbine towers - Conclusions**

- Tall turbines: an ongoing trend over 20 years.
- Towers could potential go up to 180-200m high.
- Clear benefits in terms of production and fatigue loads.
- But potential issues to watch out.

**Tall wind turbine towers - Conclusions**

- Project risks can be reduced by:
  - Lidar measurement over 3 months to decrease vertical extrapolation uncertainty (when masts are used).
  - Take adequate level of uncertainty (when no mast is installed).
  - Request Type Certification, or Design Approval at Financial Close, or adapt turbine contract accordingly (condition for Take-Over, payment milestone modification).
**502 MW of wind projects have been analyzed**

**French projects > Belgian projects**


<table>
<thead>
<tr>
<th>Installed Capacity (MW)</th>
<th>Belgium</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of projects</td>
<td>Capacity (MW)</td>
</tr>
<tr>
<td>0 - 6</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>6 - 12</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>12 - 20</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Wind Project CAPEX

**Turbine Supply Agreement Price/MW almost equal in France/Belgium; spread larger in France**


<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum ('000€/MW)</th>
<th>Maximum ('000€/MW)</th>
<th>Average ('000€/MW)</th>
<th>Median ('000€/MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>749</td>
<td>1.342</td>
<td>1.063</td>
<td>1.098</td>
</tr>
<tr>
<td>Belgium</td>
<td>893</td>
<td>1.242</td>
<td>1.084</td>
<td>1.092</td>
</tr>
</tbody>
</table>

**Substantial part of TSA/MW variation is explained by size of wind farm & year of installation but almost no country effect**

30 MW wind farm: 14.2% lower TSA/MW compared to a 9MW wind farm.  
2013 wind farm: 16.6% lower TSA/MW compared to a 2008 wind farm.
Wind Project CAPEX

Size matters: big wind farms = lower TSA/MW

Size matters:
- Average TSA price down by 15% as project size goes beyond 20MW.
- Decrease due to fixed cost (crane and erection team mob/demob split over many turbines + natural equipment discount due to volume ordered).

Higher spread of CAPEX/MW compared to TSA/MW

CAPEX, including WTG + electric and civil BOP + grid connection is approximately 1.4M€/MW on average (2007 - 2013)

<table>
<thead>
<tr>
<th>Country</th>
<th>Minimum ('000€/MW)</th>
<th>Maximum ('000€/MW)</th>
<th>Average ('000€/MW)</th>
<th>Median ('000€/MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>1.044</td>
<td>1.512</td>
<td>1.339</td>
<td>1.395</td>
</tr>
<tr>
<td>Belgium</td>
<td>1.229</td>
<td>1.564</td>
<td>1.432</td>
<td>1.433</td>
</tr>
</tbody>
</table>
Wind Project CAPEX

CAPEX/MW is mainly explained by variations in TSA/MW. 66% of CAPEX is taken by TSA-costs; other costs are typically site-specific

Capex/MW versus regression estimate

Comparison of CAPEX between Belgium & France

CAPEX breakdown

CAPEX breakdown-France (Financing cost excl.)

- 85%
- 10%
- 5%
- 1%

- BOP [electrical & civil]
- Wind Turbine-foundation
- Grid connection
- Studies and Project Management
According to EWEA, CAPEX will go down by approximately 15% by 2020.
- Average CAPEX differs from 3E’s values & literature...

... but 3E agrees with a -15% forecast.
- However, prices of turbines are now increasing again.
CAPEX Contingency-Overview

Sizing contingency is a delicate exercise and developers tend to have a strong opinion on it!

- One size does not fit all!
- Using a rule of thumb is a very (very) bad idea.
- Contingency is designed to cover additional costs that are not included in the various contracts and/or additional studies & mitigation measures.

As a consequence, sizing the contingency shall be included on a project specific basis, taking into account all available information on contracts, permits, licenses and agreements.

CAPEX Contingency-3E calculation tool (40MW, South Africa)
CAPEX Contingency

Contingency is always used, since nothing goes exactly according to the plan.

- There are always few weather delay days to pay during turbine erection (approx 15-20k€/day):
  - 2 turbines erected per month during the 2013 - 2014 winter in some projects in Belgium.
  - Some TSA contracts only include 4 - 6 days of crane per turbine, while 8 days is a better average.
- Unless the final detailed geotechnical survey is done, foundation design & price are likely to change.
- Wind turbine manufacturers are really good at claiming everything they can (even before works actually start).

Maintenance Reserve Account

Standards O&M contracts for wind turbine include:

- Scheduled maintenance.
- Unscheduled maintenance.
- All spare parts, including major components.
- Remote surveillance.

They are never “all-in” as such, but cover pretty much everything, therefore, an MRA is not required.

Non-standard O&M contracts (AOM 2000-3000 Vestas contracts, older Senvion contracts, Gamesa...) will require an MRA since major spare parts are not included.

An adequate OPEX shall include turbine O&M cost + BOP cost.
WALLONIA

Installed capacity in Belgium

Wallonia
Wallonia

Current trend

Overall trend is rather good for Belgium, but 3 issues are of great concern:

- Only 240MW out of 325MW installed capacity in 2013 was offshore.
- Only 25MW installed in Wallonia and 57MW in Flanders!
- The growth rate has been rather flat in Wallonia since 2012!
- 2014 does not look better in Wallonia (only 8 turbines erected between January and June).

Split per region

Overall trend is rather good for Belgium, but 3 issues are of great concern:

- Only 240MW out of 325MW installed capacity in 2013 was offshore.
- Only 25MW installed in Wallonia and 57MW in Flanders!
- The growth rate has been rather flat in Wallonia since 2012!
- 2014 does not look better in Wallonia (only 8 turbines erected between January and June).
Permitting in Wallonia

- Previous framework for onshore wind farm planning process: Cadre de Reference 2002.
- New Framework launched in February 2013:
  - More distance from dwellings (350m before, 4 times tip height now).
  - Requirement for turbine noise emission more stringent: 40-45-50dB(A) during night transition period - day, regardless of wind speed.
  - More mitigation measures to support biodiversity.
  - Curtailment necessary to comply with such requirements was challenged by EDORA: different curtailment strategy proposed (including distinction for winter).

Different curtailment = large revenue variation

Example (5x2MW turbines):

<table>
<thead>
<tr>
<th>General noise conditions:</th>
<th>Sectorial noise conditions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-45-50dB(A) during night-transition period-day, regardless of wind speed.</td>
<td>less restrictive for night period in the winter 43dB(A) when temperature at 22h is below 16°C</td>
</tr>
<tr>
<td>Depending turbines type and curtailment mode.</td>
<td></td>
</tr>
<tr>
<td>➢ MM100: 13%</td>
<td>➢ MM100: &lt; 1%</td>
</tr>
<tr>
<td>➢ E82: 16%</td>
<td>➢ E82: 3%</td>
</tr>
<tr>
<td>Combination with other restrictions such as bat protection:</td>
<td></td>
</tr>
<tr>
<td>➢ MM100: 16%</td>
<td>➢ MM100: 1.7%</td>
</tr>
<tr>
<td>➢ E82: 19%</td>
<td>➢ E82: 4%</td>
</tr>
</tbody>
</table>
A very large proportion of claims

Most (if not all) permits are being challenged by claims:

- A rather vague 2200 hour full-load time is used (not mentioned in any official text!) to justify a good wind resource...
- ... but nobody knows if it is based on P50 or P90!
- New curtailment strategy decrease (P50 & P90), hence 2200hr criteria never met (when based on P50).

Opponents are well organized and...

- Produce their own yield assessment studies (with lower P50 & P90...).
- They claim reports from all consultants are wrong and badly detailed.
- Attack the curtailment strategy submitted by EDORA.

As a consequence, the Conseil d’Etat (highest jurisdiction) challenges permits (even those approved by Region Wallonnie)
3E and the Wallonia case

In an effort to support developers (customers or not), 3E has taken the following steps:

- Meeting with Region Wallonne to explain methodology for wind resource assessment, with 25 civil servants present (February 2014).
- Technical note to explain why 2200hr criteria is wrong and the difference between P50 and P90 (February 2014) -> criteria seem now abandoned.

- Technical note to explain use of re-analysis wind data (MERRA) for wind resource assessment in Belgium (June 2014).
- Letter of support for individual projects, to defend 3E reports but also Tractebel and GreenPlug reports.
- Since January 2014, 20 man days spent in drafting notes and attending meetings.
Green certificates in Wallonia

Starting from January 2015, Green certificates will be structured as follows:

\[ CV = t_{CV} \times \text{Eenp} \quad \text{Equal to 1} \quad \text{[CV]} \]

\[ t_{CV} = \min \{ 2.5 \times k_{CO2} \times k_{CO} \} \quad \text{[CV/MWh]} \]

However, for wind (and Hydro and PB), the “ρ” factor is used to compensate electricity price variations (ρ is equal to 1 for the first 3 years)

\[ t_{CV} = \min \{ 2.5 \times \rho \times k_{CO2} \times k_{CO} \} \quad \text{[CV/MWh]} \]

The Million $ Question: How Will ρ Be Adjusted?

In documentation, nothing refers to how ρ will change in the future (no banding factor):

- ρ will go up if electricity price goes down.
- ρ will go down if electricity price goes up.
- This adjustment will be made to keep a 7% IRR on projects.
- As a matter of fact, electricity prices from Renewables keep on going down, so upward adjustments may be very costly for Wallonia!

Can projects be financed in this context?
Wallonia

Conclusions

- Wallonia has got a good 2020 target (3.8GW) **BUT**: 641MW installed by end of 2013.
- 8 turbines installed between January and June 2014.
- Most permits are under fire.
- Legal framework not clear (2200 full load hours target; curtailment).
- Well organized opponents.

Without strong political support, the target will not be reached (even a 1.5GW target will be difficult in this context)
EUROPEAN WIND MARKETS

Global Overview
European wind markets

Annual Market Forecast

Annual Wind Power Installations in EU (GW)

Source: EWEA
In 2013, wind market decreased by 8% compared to 2012.

But overall annual power capacity installation decreased by 20% in Europe in 2013, compared to 2012.

32% of new capacity was wind, 31% PV (and 22% Gas).

72% of new installations is in renewable energy.

86% on wind capacity installed in 2013 was onshore (against 90% in 2012).

Investment in wind was between €13 and €18 billions, including €8 - 12 billion for onshore.
EU Member states market shares for the new installed capacity in 2013 (total 11.159MW)

Support mechanisms across Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>Feed-in Tariff</th>
<th>Certificates</th>
<th>Feed-in premium</th>
<th>Tender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>Onshore/offshore</td>
<td>Offshore (from 2015)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>Onshore/Offshore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>Onshore/offshore</td>
<td>Offshore</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ireland</td>
<td>onshore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>onshore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>onshore</td>
<td>Offshore (coming)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>onshore</td>
<td></td>
<td>Offshore</td>
<td></td>
</tr>
<tr>
<td>Luxemburg</td>
<td>onshore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td></td>
<td></td>
<td>Offshore/Offshore</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>onshore</td>
<td></td>
<td></td>
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<tr>
<td>Sweden</td>
<td>onshore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>onshore</td>
<td>coming</td>
<td>coming</td>
<td></td>
</tr>
<tr>
<td>Romania</td>
<td>onshore</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>onshore</td>
<td></td>
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<tr>
<td>Portugal</td>
<td>onshore</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Spain</td>
<td>onshore</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
European wind markets

### 3E in Europe

- 3E has been working across Europe for 15 years
- Main technical advisory markets for 3E: Benelux and France
- Main customers are:

  ![Customers logos](image1)

The following slides detail these two main markets as well as the leading European market, Germany.

---

### Germany

- One of the oldest markets in Europe.
- Strongest market in Europe in 2013.
- Will keep being strong in the future.
- New support mechanism from August 2014 (Premium), tariff varying from 88€/MWh to 58€/MWh, depending on wind regime.

<table>
<thead>
<tr>
<th>Year</th>
<th>New Capacity</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>2297</td>
<td>30989</td>
</tr>
<tr>
<td>2013</td>
<td>3238</td>
<td>33730</td>
</tr>
<tr>
<td>2014</td>
<td>4200</td>
<td>37930</td>
</tr>
<tr>
<td>2015</td>
<td>3900</td>
<td>41830</td>
</tr>
<tr>
<td>2016</td>
<td>3200</td>
<td>45030</td>
</tr>
<tr>
<td>2017</td>
<td>3200</td>
<td>47030</td>
</tr>
<tr>
<td>2018</td>
<td>2000</td>
<td>49430</td>
</tr>
</tbody>
</table>
Belgium

- Flanders has less ambitious targets, but is more stable in terms of annual installation rate.
- Wallonia has a 3.8GW target by 2020, but only 27MW installed in 2013!
- Bureaucratic obstacles slowing down growth.
- Uncertainties over green certificates is an issue for financing.
- Offshore: major bottleneck – Stevin – seems to be solved.
- Offshore new wind farms -> FIP instead of a fixed subsidy/MWh

<table>
<thead>
<tr>
<th>Year</th>
<th>New Capacity</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>297</td>
<td>1375</td>
</tr>
<tr>
<td>2013</td>
<td>276</td>
<td>1651</td>
</tr>
<tr>
<td>2014</td>
<td>250</td>
<td>1901</td>
</tr>
<tr>
<td>2015</td>
<td>360</td>
<td>2261</td>
</tr>
<tr>
<td>2016</td>
<td>300</td>
<td>2561</td>
</tr>
<tr>
<td>2017</td>
<td>350</td>
<td>2911</td>
</tr>
<tr>
<td>2018</td>
<td>350</td>
<td>3261</td>
</tr>
</tbody>
</table>

France

- 2nd best wind potential in Europe.
- Lagging behind large European countries.
- Political and legal uncertainties up to 2014, now cleared up.
- New Feed-in Tariff from 2014 (85€/MWh for 10 years, then decreasing up to 15 years, depending of wind conditions)

<table>
<thead>
<tr>
<th>Year</th>
<th>New Capacity</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>814</td>
<td>7623</td>
</tr>
<tr>
<td>2013</td>
<td>631</td>
<td>8254</td>
</tr>
<tr>
<td>2014</td>
<td>800</td>
<td>9054</td>
</tr>
<tr>
<td>2015</td>
<td>1100</td>
<td>10154</td>
</tr>
<tr>
<td>2016</td>
<td>1326</td>
<td>11480</td>
</tr>
<tr>
<td>2017</td>
<td>1700</td>
<td>13180</td>
</tr>
<tr>
<td>2018</td>
<td>1800</td>
<td>14980</td>
</tr>
</tbody>
</table>
The Netherlands

- New SDE+ scheme in 2013: premium on top of market price, for 12-15 years.
- Total subsidies per year are capped, so “first come first served” principle.
- 2020 target: 6GW onshore (4GW offshore).
- 11 selected areas for onshore wind farm development for 100MW+ project size.

<table>
<thead>
<tr>
<th>Year</th>
<th>New Capacity</th>
<th>Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>119</td>
<td>2391</td>
</tr>
<tr>
<td>2013</td>
<td>303</td>
<td>2693</td>
</tr>
<tr>
<td>2014</td>
<td>360</td>
<td>3053</td>
</tr>
<tr>
<td>2014</td>
<td>475</td>
<td>3528</td>
</tr>
<tr>
<td>2015</td>
<td>750</td>
<td>4278</td>
</tr>
<tr>
<td>2016</td>
<td>700</td>
<td>4978</td>
</tr>
<tr>
<td>2017</td>
<td>550</td>
<td>5528</td>
</tr>
</tbody>
</table>

A Changing Investment Landscape

- Market for onshore wind assets less dependent on general economic development than other industries (mostly due to subsidies)
- Increase in number of transactions driven from supply as well as from demand side
  - Reallocation of asset classes (onshore vs. offshore)
    - Geographical reallocation of assets (Europe vs. Americas)
    - Distressed companies divested assets to improve cash flows
  - Increasing portion of institutional investor active
**Different Investors, Different Motivations**

- Institutional investors: high liquidity and pressure to invest, searching for moderate yield and stable cash flows.
- Utilities: focus on core markets (sale of Iberdrola, Dong, Enel onshore business)
- Municipalities: built up of renewable portfolio as decentralized energy sources (Swiss utilities, German municipalities).
- Corporate players: IKEA, Google and others willing to enter market due to commitment to green balance sheet (started in the US, now in Europe).

**Strategic Investors vs. Institutional Investors**

<table>
<thead>
<tr>
<th>Strategic Investors</th>
<th>Institutional Investors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to take risk</td>
<td>Available funds</td>
</tr>
<tr>
<td>Corporate responsibility</td>
<td>Lack of alternative investment</td>
</tr>
<tr>
<td>Obligation to fulfill clean energy targets</td>
<td>Strongly IRR focused</td>
</tr>
<tr>
<td></td>
<td>Not so keen on risk</td>
</tr>
<tr>
<td></td>
<td>Significant transaction experience</td>
</tr>
</tbody>
</table>
European wind markets

**IRR requirements for different investors**

![Graph showing IRR requirements for different investors]

Source: Yonge Archer Capital/3E, IRR Feedback (Corporate Finance Research)

Brussels
Toulouse
Beijing
Istanbul
Cape Town
Milan

www.3E.eu