Do we still need Airborne Wind Energy?

AWEC 2017
Freiburg, 5-6 October 2017

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The world in 2004…

Source: NASA

15 September 19, 2017
The Problem: Renewable Energy Prices

Wind and solar costs

**Wind**

- 2004 wind LCOE: €150/MWh

**Solar**

- 2004 c-Si module price: $4.1/W

*Source: Bloomberg New Energy Finance*
The Solution: Airborne Wind Energy

“Renewables are growing fast, but can they grow fast enough to compensate for the depletion of fossil fuels? We have a problem of cost.”

Develop Renewable Energy Cheaper Than Coal (RE<C)

Introduction

In the fall of 2007, Google launched an initiative called “Renewable Energy Cheaper than Coal” or
Lower Installation Costs

Source: IRENA
Higher output due to High-Altitude Winds

IRENA: Global Atlas, Map data: DTU 2015, OpenStreetMap contributors
The world today...

Image: NASA

35 September 19, 2017

www.airbornewindeurope.org
Wind Energy Growth

Evolution of wind turbine heights and output

Sources: Various; Bloomberg New Energy Finance
Prices Fall Dramatically

Wind and solar experience curves

**Wind**

- Learning rate = 19%

**Solar**

- Learning rate = 24-28%

*Source: Bloomberg New Energy Finance*
Renewable Energy Price Records 2017

Unsubsidised clean energy world records 2017

Solar PV
- Country: United Arab Emirates
- Bidder: Marubeni and Jinko Solar
- Signed: 2017
- Construction: 2019
- Price: US$ 2.42 c/kWh

Onshore wind
- Country: Morocco
- Bidder: Enel Green Power
- Signed: 2016
- Construction: 2018
- Price: US$ 3.0 c/kWh

Offshore wind
- Country: Germany
- Bidder: DONG/EnBW
- Signed: 2016
- Construction: 2024
- Merchant Price: US$ 4.9 c/kWh

Source: Bloomberg New Energy Finance; Images Siemens; Wikimedia Commons; Masdar
Renewable energy proportion of power generation, 2006-16

Note: Excludes large hydro  Source: Bloomberg New Energy Finance
The world in 2040

*Image: NASA*
Solar and wind dominate the future of electricity

Global cumulative installed capacity: 2016

- Coal: 30%
- Onshore wind: 17%
- Hydro: 17%
- Nuclear: 5%
- Oil: 6%
- Gas: 24%
- Utility-scale PV: 3%
- Small-scale PV: 2%

6,719GW

Global cumulative installed capacity: 2040

- Gas: 14%
- Coal: 13%
- Nuclear: 3%
- Hydro: 12%
- Onshore wind: 14%
- Utility-scale PV: 22%
- Small-scale PV: 10%
- Flexible capacity

13,919GW

Source: Bloomberg New Energy Finance, NEO 2017

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Solar and wind attract 60% of new investment in power generating capacity

Investment, by technology, 2017-2040

($ trillion - 2016 real)

- Wind: $3.3 trillion
- Solar: $2.8 trillion
- Nuclear: $1.4 trillion
- Hydro: $1.1 trillion
- Gas: $0.8 trillion
- Coal: $0.7 trillion

Source: Bloomberg New Energy Finance, NEO 2017
Demand response and batteries meet peak and balance the grid

![Graph showing the increase in demand response and batteries from 2012 to 2040.]

### Top 5 markets in 2040

<table>
<thead>
<tr>
<th>Country</th>
<th>Capacity (GW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>343GW</td>
</tr>
<tr>
<td>U.S.</td>
<td>200GW</td>
</tr>
<tr>
<td>India</td>
<td>127GW</td>
</tr>
<tr>
<td>Japan</td>
<td>62GW</td>
</tr>
<tr>
<td>Germany</td>
<td>30GW</td>
</tr>
</tbody>
</table>

*Source: Bloomberg New Energy Finance*
Tipping point 1: new vs new

**China**

$/MWh (real 2016)

- Utility-scale PV
- Onshore wind

**U.S.**

$/MWh (real 2016)

- Utility-scale PV
- Onshore wind

*Source: Bloomberg New Energy Finance, NEO 2017*
Tipping point 2: new vs existing

**Germany**

$/MWh (real 2016)

2017 2020 2025 2030 2035 2040

- Utility-scale
- PV
- Onshore wind
- CCGT
- Coal

**China**

$/MWh (real 2016)

2017 2020 2025 2030 2035 2040

- Utility-scale
- PV
- Onshore wind
- CCGT
- Coal

Source: Bloomberg New Energy Finance, NEO 2017

September 19, 2017
Coal has peaked

Coal production
Mt/yr

Coal consumption
Mt/yr

Note: Adjusted to standard coal equivalent

Source: Bloomberg New Energy Finance, BP Statistical Review

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Do we still need Airborne Wind Energy?
The big challenge
High renewable penetrations

- 13 February 2017
  SPP
  52% wind

- 25 December 2016
  Scotland
  153% wind

- 9 July 2015
  Denmark
  140% wind

- 9 April 2017
  UK 56%
  wind & solar

- May 2016
  Germany
  67% wind & solar

- November 2015
  Spain
  70% wind

- November 2017
  ERCOT
  45% wind

- 26 December 2014
  South Australia
  61% wind & solar

Source: Bloomberg New Energy Finance, various
Total generation

Winter

Low carbon generation

Summer

Flexible generation

Source: Bloomberg New Energy Finance
New orthodoxy

By 2040...

1/3 of electricity will be wind and solar

1/3 of cars and light trucks will be electric

The global economy will be 1/3 more energy efficient

...too hard

Shipping/air/freight

Land-use/deforestation

Petrochemicals

Industry

Energy access

Heat

Source: Bloomberg New Energy Finance, Tesla, Wallpaper Mania, Cleantechnica
New orthodoxy

Rebasted to 100 in 2014

BNEF NEO emissions
IEA NPS total emissions
IEA NPS power sector emissions

Prove it wrong!

Source: Bloomberg New Energy Finance, IEA

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Today’s Problems:

- Non-reliable, fluctuating generation
  (What happens when the sun does not shine and the wind does not blow?)

- Requires expensive storage and grid enhancement

- Still limits renewable % of electricity in the grid

- Current technologies not enough to meet climate goals
  (Due to fluctuation and not due to price)
Can AWE be the solution? High Capacity Factor
High Capacity Factor

Comparison of Ampyx AP4 vs Vestas V90 at onshore conditions (Rossemdorf), annual results
How Airborne Wind Energy is a solution for today’s problems

Lower Storag / Grid Costs

High Capacity Factor

Higher total renewable %

Rugged Terrain

What can AWE offer?

That solves the Problems of 2020 - 2040?

Floating Offshore

Cheap(er) Energy?

Low Wind Sites

Ship Propulsion
Yes, we do still need Airborne Wind Energy
Airborne Wind Europe: Helping the AWE industry to overcome its common challenges
Financing – Storytelling

Creating a good story

Why do we still need Airborne Wind Energy?

Substantiating Story

- Wind Data
- Impact on Grid / Storage
- Power Curves
- Total Cost of Energy System

Telling the Story

- Press Work
- get AWE in future energy scenarios
- Policy Makers
- Research Agendas
Airborne Wind Europe: Cooperation of all players

- AWE OEMs
- Utilities
- Suppliers
- Universities
The world is not already saved
We do need Airborne Wind Energy!