GREEN MARKETS,
SUSTAINABLE BUSINESS

Centre for Enterprise, Markets and Ethics, 2 March 2017

Michael Liebreich
Chairman of the Advisory Board
Twitter: @mliebreich
THE LEGACY ENERGY SYSTEM
Note: Total values include estimates for undisclosed deals. Includes corporate and government R&D, and spending for digital energy and energy storage projects (not reported in quarterly statistics). Excludes large hydro.

Source: Bloomberg Intelligence, Bloomberg New Energy Finance
Note: Total values include estimates for undisclosed deals. Includes corporate and government R&D, and spending for digital energy and energy storage projects (not reported in quarterly statistics). Excludes large hydro.

Source: Bloomberg Intelligence, Bloomberg New Energy Finance
Note: New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.

Source: Bloomberg New Energy Finance
INVESTMENT IN POWER CAPACITY, 2008–15 ($BN)

Source: UNEP, Bloomberg New Energy Finance
RENEWABLE ENERGY PROPORTION OF POWER GENERATION, 10 YEARS TO 2015 (%)

Canada 61% 67%
US 9% 14%
Canada
US
Spain 21% 37%
UK 5% 26%
Denmark 16% 69%
France 12% 17%
Germany 12% 36%
Italy 20% 40%
Denmark
UK
Spain
France
Germany
Italy
Japan 10% 15%
Australia 10% 17%
Brazil 89% 79%
South Africa 1% 3%
India 17% 18%
South Africa
Brazil
India
Note: Includes hydro Source: BP Statistical Review of Energy, Bloomberg New Energy Finance
2011 UNSUBSIDISED CLEAN ENERGY WORLD RECORDS

<table>
<thead>
<tr>
<th>ONSHORE WIND</th>
<th>SOLAR PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>US$ 6.2 cents/kWh</td>
<td>US$ 17 cents/kWh</td>
</tr>
</tbody>
</table>

Source: Bloomberg New Energy Finance; Images: Siemens; Wikimedia Commons
### 2016 UNSUBSIDISED CLEAN ENERGY WORLD RECORDS

#### ONSHORE WIND

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<tr>
<th>Location</th>
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<th>Construction</th>
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<tbody>
<tr>
<td>Morocco</td>
<td>Enel Green Power</td>
<td>January 2016</td>
<td>2018</td>
<td>US$ 3.0 c/kWh</td>
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#### SOLAR PV

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<tr>
<td>Peru</td>
<td>Enel Green Power</td>
<td>February 2016</td>
<td>2017</td>
<td>US$ 4.8 c/kWh</td>
</tr>
</tbody>
</table>

Source: Bloomberg New Energy Finance; Images Siemens; Wikimedia Commons
2016 UNSUBSIDISED CLEAN ENERGY WORLD RECORDS

ONSHORE WIND

Location: Morocco
Bidder: Enel Green Power
Signed: January 2016
Construction: 2018
Price: US$ 3.0 c/kWh

SOLAR PV

Location: Coahuila, Mexico
Bidder: Enel Green Power
Signed: March 2016
Construction: 2018
Price: US$ 3.6 c/kWh

Source: Bloomberg New Energy Finance; Images: Siemens; Wikimedia Commons
### 2016 UNSUBSIDISED CLEAN ENERGY WORLD RECORDS

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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dubai</td>
<td>Masdar Consortium</td>
<td>May 2016</td>
<td>2019</td>
<td>US$ 2.99 c/kWh</td>
</tr>
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Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons
## 2016 UNSUBSIDISED CLEAN ENERGY WORLD RECORDS

### ONSHORE WIND

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<td>Chile</td>
<td>Solarpack Corporation</td>
<td>August 2016</td>
<td>2019</td>
<td>US$ 2.91 c/kWh</td>
</tr>
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Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons
WIND AND SOLAR EXPERIENCE CURVES

**Solar PV Module Cost ($/W)**

- Solar costs have fallen >99% since 1976
- 90% since 2004

**Onshore Wind Levelised Cost* ($/MWh)**

- Wind costs have fallen 60% since 2004

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**Note:** Pricing data has been inflation corrected to 2014. We assume the debt ratio of 70%, cost of debt (bps to LIBOR) of 175, cost of equity of 8%. *Data is for Northern Europe.

**Source:** Bloomberg New Energy Finance

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**Note:** Prices are in real (2015) USD. ‘Current price’ is $0.4/W

**Source:** Bloomberg New Energy Finance, Maycock
CAPACITY FACTOR IMPROVEMENTS

LONGER BLADES

LOW-WIND TURBINES AT HIGH-WIND SITES

SITE-OPTIMISED POWER CURVES

HIGHER TOWERS

Source: Siemens, Nordex, GE, Vestas
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – eg renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2000
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2001
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – eg renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2002
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – eg renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2003
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards

Feed-in tariffs/premiums

Mixed

Countries with auction or tender programmes

2004
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariffs/premiums
Mixed
Countries with auction or tender programmes

2005
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – eg renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2006
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2007
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – eg renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2008
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2009
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards

Feed-in tariff/premiums

Mixed

Countries with auction or tender programmes
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g., renewable energy auctions, certificate schemes, renewable portfolio standards

Feed-in tariff/premiums

Mixed

Countries with auction or tender programmes

2011
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards

Feed-in tariff/premiums

Mixed

Countries with auction or tender programmes

2012
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards

Feed-in tariff/premiums

Mixed

Countries with auction or tender programmes

2013
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2014
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards
Red: Feed-in tariff/premiums
Green: Mixed
Countries with auction or tender programmes

2015
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Market-based mechanisms – e.g. renewable energy auctions, certificate schemes, renewable portfolio standards
Feed-in tariff/premiums
Mixed
Countries with auction or tender programmes

2016
CARS AND TRUCKS IN USE WORLDWIDE, 2016
1.3 billion

Source: Bloomberg New Energy Finance, International Organization of Motor Vehicle Manufacturers
EV LITHIUM-ION BATTERY PRICES HAVE FALLEN 73% since 2010

Notes: This includes cells plus pack prices. For years where there were two surveys, the data in this chart is an average for the year. Prices are nominal.

Source: Bloomberg New Energy Finance
EV MASS MARKET / SECOND CARS
$30,000 + 200 MILES RANGE

Tesla Model 3
BMW i3
VW e-Golf
Chevy Bolt
Renault-Nissan

Images: Tesla, BMW, VW, GM, Nissan
PARIS

The Paris Agreement is a monumental triumph for people and our planet.

Ban Ki Moon, former UN SG

This is a turning point. This gives us the best possible shot to save the one planet we got.

Barack Obama, US President

It is a sign of hope. It can have a positive influence on the living conditions of billions of people.

Angela Merkel, Chancellor of Germany

Together we have opened the door to a sustainable and climate-safe future for all.

Christiana Figueres, former head, UNFCCC

The Paris Agreement has been an unprecedented historic success.

Miguel Arias Cañete, European Commissioner for Climate Action and Energy

Today's agreement signals nothing less than a renaissance for humankind.

Mr. Mogens Lykketoft, President, UN General Assembly
GLOBAL GREENHOUSE GAS EMISSIONS (GTCO2)

Source: UNFCCC, UNEP, Climate Action Tracker, Bloomberg New Energy Finance

Historical emissions
Pre-COP21 pledges
GLOBAL GREENHOUSE GAS EMISSIONS (GTCO2)

Source: UNFCCC, UNEP, Climate Action Tracker, Bloomberg New Energy Finance
GLOBAL GREENHOUSE GAS EMISSIONS (GTCO2)

Source: UNFCCC, UNEP, Climate Action Tracker, Bloomberg New Energy Finance
GLOBAL PRIMARY ENERGY SUPPLY (MTOE)

Source: Bloomberg New Energy Finance
GLOBAL PRIMARY ENERGY SUPPLY, 1975 (MTOE)

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total includes bioenergy and hydro.

Source: Bloomberg New Energy Finance, IEA
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Source: Bloomberg New Energy Finance, IEA
GLOBAL PRIMARY ENERGY SUPPLY, 1990 (MTOE)

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Source: Bloomberg New Energy Finance, IEA
GLOBAL PRIMARY ENERGY SUPPLY, 2005 (MTOE)

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total includes bioenergy and hydro.

Source: Bloomberg New Energy Finance, IEA
Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total includes bioenergy and hydro.

Source: Bloomberg New Energy Finance, IEA
GLOBAL PRIMARY ENERGY SUPPLY, 2015 (MTOE)

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total includes bioenergy and hydro.

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Source: Bloomberg New Energy Finance, IEA
GLOBAL PRIMARY ENERGY SUPPLY (MTOE)

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total includes bioenergy and hydro. Paris illustrative scenario assumes some carbon capture.

Source: Bloomberg New Energy Finance, IEA
CLEAN ENERGY CAPITAL REQUIREMENT TO 2030 ($BN)

Note: Global Futures figures from 2008 restated to reflect current investment calculation methodology.

CLEAN ENERGY CAPITAL REQUIREMENT TO 2030 ($BN)

Average 2010 - 2016 $300 billion

Note: Global Futures figures from 2008 restated to reflect current investment calculation methodology

WHY IS ALL THIS SO HARD?

1. Challenge of information (technology, engineering, human behaviour, economics etc)
2. Challenge of strategy (decision-making in uncertainty, poverty reduction vs growth)
3. Challenge of leadership (political, business, civic society)
4. Challenge of implementation (unintended consequences, agenda creep)
5. Challenge of inertia (social, physical, financial, incumbency)

Source: Bloomberg New Energy Finance
Thanks!

Michael Liebreich
Twitter: @MLiebreich

MARKETS
Renewable Energy
Energy Smart Technologies
Advanced Transport
Gas
Carbon and RECs

SERVICES
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Asia Pacific Service
EMEA Service
Applied Research
Events and Workshops

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sales.bnef@bloomberg.net