Corporate Sourcing of Renewables
IRENA Cost Analysis

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All results are PRELIMINARY and subject to change.

Final report to be released in June 2016.
IRENA analysis in support of Corporate Sourcing of Renewables (CEM7 Campaign)

Costs and economics of renewables are central

Ability to scale beyond high margin corporates critical to ambition

Campaign needs to reach SME

RE business case: Cost data and analysis brings transparency
Power generation database

15000 utility-scale projects, 9000 with LCOE data
New renewable power technologies: Rapidly maturing

Note: each circle represents a utility-scale project, centre of circle is LCOE value and diameter of circle the project size.
PPAs show costs are decreasing

Projects in a wide range of technologies and locations are being offered at very low long-term contract prices

Today’s record low PPA prices are tomorrow’s average
Renewables: The cost effective solution

Note: each circle represents a utility-scale project, centre of circle is LCOE value and diameter of circle the project size.
Costs will continue to fall for solar and wind power technologies to 2025

- Large cost differentials
- Continued technology innovation
- Growing scale of markets

Policy framework critical to unlocking largest savings
SOLAR PHOTOVOLTAICS
Utility scale PV total system costs to 2025

Large average cost reduction potential

BoS dominates potential

Not widely appreciated by policy makers
PV Module costs to 2025

Largest cost reductions from polysilicon production and cell-to-module production

**Value Chain**

- **Bottom-up estimate**

**Technology**

<table>
<thead>
<tr>
<th></th>
<th>mono</th>
<th>multi</th>
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</thead>
<tbody>
<tr>
<td><strong>USD/Wp</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>0.0</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>0.2</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>0.4</strong></td>
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<td></td>
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<tr>
<td><strong>0.6</strong></td>
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</table>

- **Total module costs 2015**
- **Total module costs 2025**

**Value Chain**

- **Poly to wafer**
- **Wafer to cell**
- **Cell to module**

**Continued cell efficiency improvements (22%-25% in 2025)**

**Cheaper Poly-silicon**

- increased reactor capacity
- reduced electricity consumption
- uptake of newer manufacturing processes

**Cell-Mod Process**

- Module cost expected to drop:
  - one-third for mono-crystalline modules
  - one-fifth for multi-crystalline modules

**Other**

- Sawing process, thinner wafers, process control improvements.
- Silver paste and materials use reductions
Solar PV: BoS costs to 2025

BoS costs for utility-scale solar PV plant could fall by between 65% and 71% between 2015 and 2025.

Why?
- market and supply chain increased maturity
- Lower perceived risks => lower margins

Soft costs
- Expected to contribute between 43%-46%

Hardware
- BOS hardware costs decrease expected to contribute another 30-32% to the potential

Soft costs alone to account about half of the reduction potential
Policies key to BoS cost reductions

<table>
<thead>
<tr>
<th>Country</th>
<th>Current 2015 USD/Wp</th>
<th>Hardware</th>
<th>Installation</th>
<th>Soft Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Germany</td>
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</table>

- **Technical potential -80%**
- **Best practice -30%**

Factor 3 difference between average BoS utility-scale costs in most competitive to least competitive market!
ONSHORE WIND
Onshore wind

The cost of onshore wind farms will continue to fall

Historically every doubling of global capacity has meant:

- 6% declined in investment costs
- 9% decline in LCOE

1983-2014

- Global weighted average investment costs declined by two thirds:
  - USD 4766/kW to USD 1623/kW

Drivers

- Increased economies of scale
- Broader market (100+ countries)
- Greater competition in VC
- Technology innovation

US

1998-2014

- Avg. turbine capacity: +170%
- Avg. Hub height: +48%
- Avg. rotor diam.: +108%

Technology innovation

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Hub Height</th>
<th>Rotor diameter</th>
<th>Yield (for same wind resource)</th>
<th>Specific kW costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase</td>
<td>Increase</td>
<td>Increase</td>
<td>Decrease (for same wind resource)</td>
<td>Decrease (for same wind resource)</td>
</tr>
</tbody>
</table>
Onshore wind: LCOE

Capacity factors have doubled due to technology improvements and have caused the LCOE to fall faster than installed costs

1983-2014

LCOE:
- USD 0.38/kWh to USD 0.07/kWh (-81% fall)

Key Drivers
- Technological improvements: have been rapid and are still ongoing

Other
- lower O&M costs also have been driving LCOE down
Onshore wind: LCOE

LCOE reductions are ongoing and new technology improvements are continuously deployed.

- Improved blade design
- Pitch and yaw control
- Taller towers
- Larger capacity turbines
- Higher hubs
- Larger rotor diameters

LCOE (wider adoption of technology improvements) decline by **20-30%** by 2025.

**Contribution to LCOE reduction potential to 2025**

- Installed costs: 50%
- Higher capacity factors: 40%
- Reduced O&M: 10%
OFFSHORE WIND
Offshore wind: Installed costs

There are incremental opportunities to reduce capital costs by 2025 across the entire wind farm, from interconnection to project development.

Projected installed cost reductions for offshore wind, 2015 to 2025

Inst. costs
Reduction driven by:
- construction and installation (about 60% of total cost reduction potential)

Other
- Incremental cost reductions for turbine rotors and nacelles
Offshore wind: LCOE

Though the technology is still in its infancy (12GW end 2015), next generation offshore projects could experience LCOE decreases of 30% to 40% by 2025.

<table>
<thead>
<tr>
<th>Year</th>
<th>LCOE ($/MWh)</th>
</tr>
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<tbody>
<tr>
<td>2015</td>
<td>200</td>
</tr>
<tr>
<td>2015-2025</td>
<td>LCOE reduction</td>
</tr>
<tr>
<td>2030</td>
<td>150</td>
</tr>
</tbody>
</table>

LCOE could decrease:
- 30% to 40%

Drivers:
- Reduced cost of capital (larger pool of experienced developers, maturity of local markets, decreased perceived risks).

Larger Turbines:
- Shift from large 6 MW turbines to very large (8 MW+)
- Blade and drivetrain improvements

Increased capacity factors
- Lower downtime
- Lower O&M Costs

Source: BVG Associates
CONCENTRATING SOLAR POWER
CSP: a set of technologies

- Deployment is in its infancy (~5 GW)
- Cost reduction potential is good. IRENA analysis is focusing on parabolic trough (PT) and solar tower (ST)
- Solar towers have greater cost reduction potential with higher operating temperatures and lower cost thermal energy storage
- Cheap thermal energy storage allows dispatchable power -> potentially more valuable generation (particularly in high RE scenarios)
Concentrating solar power

Deployment in its infancy!
CAPEX could decline by one-third by 2025

Plant Efficiency: 15% currently to 17% by 2025

Plant Efficiency: 15.5% currently to 18% by 2025

PT -31% CAPEX (15-25)
- USD 5550/kW to USD 3800/kW 2025

ST -35% CAPEX (15-25)
- USD 5450/kW to USD 3600/kW

Indirect EPC costs + Owner’s costs also major contributors to reduction potential
The solar field

By 2025 CAPEX for the solar field could decrease by 23% for parabolic through (PT) and by 27% solar tower (ST) technologies.

PT -23%
Switch to molten salt as HTF towards 2025

ST -27%
Drives improvements
Structural design
More efficient assembly procedures

Aperture widths ~10 m → less loops → lower component costs (found, receivers, pylons)

Reduces investment costs
Concentrating solar power

By 2025 the LCOE of both parabolic trough and solar tower technologies will decrease about 35%

Main driver:
- Lower capital investment costs

Output:
- Assuming medium irradiance (DNI = 2550 kWh/m²)
- PT electricity output: +7.6%
- ST electricity output: +8.4%

LCOE:
- 2015: USD 15-19/kWh
- 2025: USD 0.09/kWh to USD 0.12/kWh for PT
- USD 0.08/kWh to USD 0.11/kWh for ST
Available online
Reports, presentations, events, high-res charts

www.irena.org/costs

LCOE ranges and averages

www.irena.org/resource

Additional functionality and data detail coming 2015 to REsource
Upcoming cost analysis: 2016/17

IRENA PV parity indicators
Global onshore wind learning curve
Cost of RE for stationary applications
RE power cost reduction potentials
RE and financing costs
Solar PV costs in Africa
Historical RE power generation investment
Renewable power generation cost updates 2016 and 2017