Power Sector Costing Study Update

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Rationale

- Assist government decision making
- Economics are a key decision factor
- The cost of renewables have declined rapidly in recent years
- Decision making is often based on outdated numbers
- Cost figures are often not fact based and therefore coloured by opinion of the author
- Cost data vary by project, country and over time

- IRENA strives to become a source of objective cost data that enable cost comparisons
- This will be complemented with an assessment of benefits for cost/benefit analysis
- Business perspective will be complemented with macro-economic perspective (PACB)

- 2011 focus power sector data, followed by transportation sector (2012) and stationary applications
- For the time being no cost competitiveness analysis
Cost indicators

- Cost can be measured in many ways
- A simple method is preferable
- Three indicators have been selected:
  - Equipment cost (factory gate FOB and delivered at site CIF)
  - Project cost
  - Levelized cost of electricity LCOE (ONE possible measure of attractiveness)
- Trends, most recent year and 5-year outlook (learning curves and market outlook)
- Available information is usually limited to prices
  - Strictly speaking price indicators
  - Long term, prices are a function of production cost
  - Short term, profit margins can vary and prices and cost may diverge
Two step approach:

- Literature/BNEF/tender etc data
- Own project data collection with focus Africa and Asia (in-kind contribution Germany)
- Transport cost
- Import levies

Project development:
- Site preparation
- Grid connection
- Working capital
- Auxiliary equipment
- Non-commercial cost

Operation & Maintenance:
- Cost of finance
- Resource quality
- Capacity factor
- Life span

LCOE:
Levelized cost of Electricity
(Discounted cost equal discounted revenues)

10 power technologies
IEA data review
Working papers launched April 2012
Overall insights

- Price data are readily available, cost data less so: often mixed up while trends may differ
- Equipment cost account for half to three quarters of project cost
- Typical project cost in many cases higher than data from literature
  - Important economies of scale. Especially very small projects tend to show a wide cost spread.
  - Infrastructure needs vary
  - Split commercial and development/state projects
- Major differences in financing conditions can make a factor two difference for LCOE
  - Equity:debt ratio between 80:20 to 20:80
  - Typical average cost of capital in Africa more than 20%
SOLAR - PV
Module 60% of system cost, BOS other 40%

Cost Breakdown of Conventional U.S. PV Systems, 2010

- Installed Cost (2010 $/Wdc)
  - Module: $3.50
  - Balance of System: $3.75

BoS Detail:
- Structural Installation
- Racking
- Site Prep, Attachments
- Electrical Installation
- Wiring, Transformer
- Inverter
- Business Processes

Source: Lionel Bony etc., Achieving Low Cost, Solar PV, 2010
Residential installed PV system prices, first half 2011

Larger systems are cheaper:
Lowest price USD2100-3000/kW

Wide cost ranges
Significant differences between countries

Source: IRENA Study, 2011
**Rapid and predictable cost reductions for PV modules**

*Learning curve: constant % cost reduction per doubling installed capacity*

<table>
<thead>
<tr>
<th>Year</th>
<th>Crystalline Price</th>
<th>Thin film Price</th>
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<tbody>
<tr>
<td>1979</td>
<td>$10.00</td>
<td>$0.10</td>
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<tr>
<td>1992</td>
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<td>2004</td>
<td>$1.00</td>
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<tr>
<td>2006</td>
<td>$1.30-1.50</td>
<td>$1.05</td>
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<td>2010</td>
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<td>$1.05</td>
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<td>2011</td>
<td>$1.30-1.50</td>
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<td>2014</td>
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<tr>
<td>2015</td>
<td>$1.08</td>
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</table>

22% price reduction for each doubling of cumulative installed capacity

2006 c-Si price increase due to polysilicon shortage

Source: Mints, Navigant, Bloomberg NEF, First Solar, NREL PV cost Model

**Next doubling**

70 GW

2-3 years

(22% cost reduction)
Module efficiency projections

<table>
<thead>
<tr>
<th>Technology</th>
<th>2010</th>
<th>2015</th>
<th>2015 cost reduction impact</th>
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<tbody>
<tr>
<td>c-Si</td>
<td>14%</td>
<td>16%</td>
<td>-12%</td>
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<tr>
<td>Thin film si</td>
<td>9%</td>
<td>11%</td>
<td>-18%</td>
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<tr>
<td>CdTe</td>
<td>11-12%</td>
<td>13%</td>
<td>-9% to -15%</td>
</tr>
<tr>
<td>CIGS rigid</td>
<td>11-12%</td>
<td>14%</td>
<td>-14% to -20%</td>
</tr>
<tr>
<td>CIGS flex</td>
<td>10-11%</td>
<td>13-14%</td>
<td>-15% to -30%</td>
</tr>
</tbody>
</table>

Sources: Lux Research, 2010
SOLAR CSP
CSP Project cost breakdown

Parabolic trough

Solar tower

Source: Fichtner, 2010
LCOE of parabolic trough

10% discount rate, SW US insolation conditions
Source: IRENA Analysis
WIND ONSHORE
Typical wind project cost structure

**Turbine 65% of cost**

**Tower and blade are key cost components**

**Onshore Cost Distribution**

- Wind Turbines, 64%
- Foundation, 16%
- Planning & Miscellaneous, 9%
- Grid connection, 11%

**Project investment cost 2010:**

- Onshore USD 2 000/kW
- Offshore USD 4 000/kW
Wind Auctions Brazil

Auction 2009
Delivery 2012

Auction 2010
Delivery 2013

-30%

Auction 2011
Delivery 2014
Learning curve for turbines

Strong anomalies in recent years; further analysis needed

Doubling of capacity 240 GW
42 GW added in 2011
5-6 years for next doubling?

Commodity prices only part of the Explanation

Higher turbines yield higher CF

Source: Bloomberg New Energy Finance, February, 2011
Set of Technologies:

- Stoker boiler, Gasification, Digester, Biogas (Landfill Gas, Anaerobic digestion)
- Feedstock cost account for a large share of the total cost
  - Biomass feedstock prices depend on quality, quantity, availability, moisture content
  - Biomass handling cost can have a high impact on final cost
- A market for pellets and woodchips has emerged in recent years
- Biopower plants require long term contracts for agricultural and forest residue supply
- Biomass co-generation systems are usually linked to industrial, agricultural and crop processing plant where the waste heat can be used in the process
Typical range of equipment costs
Typical Project Cost Structure

Source: CCC, 2011

Equipment cost account for 45%-70% of total cost
Typical LCOE ranges
Feedstock from 10$/ton (9 GJ/ton) to 160 $/ton (17 GJ/ton)
Renewable Project Cost and Prices Latin America

USD/MWh

Argentina | Brazil | Chile | Argentina | Brazil | Chile | Brazil | Chile | Argentina | Brazil | Chile

Wind | SHP | Biomass | Solar

Costs | Prices
Next steps in cost analysis 2012

• Issue working papers
• Prepare a report with summary of working paper findings and questionnaire
  ▪ Explain regional/country differences
• Make a start with cost data collection for transportation fuels
• Develop a software based system to facilitate data roundup with the help of member countries
Thank you!

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