Measures of International Manufacturing and Trade of Clean Energy Technologies


Jill Engel-Cox
Director, Clean Energy Manufacturing Analysis Center (CEMAC)
Debbie Sandor, David Keyser, and Margaret Mann, NREL

www.manufacturingcleanenergy.org

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Communication of Results

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Manufacturing Clean Energy Blog

Manufacturing Clean Energy is the official blog of the Clean Energy Manufacturing Analysis Center (CEMAC). It features insights from CEMAC staff, partners, and guests. To contribute to Manufacturing Clean Energy, contact us.

Hydropower Turbine Market and Trade Values: A closer look at small hydro turbines in the U.S.

December 14, 2016
By Parthiv Kanaujia, NREL, and Megan Johnson, ORNL.

Hydropower has been a long-term stable power generation source in the U.S. for decades, and research shows there is significant electricity generation potential from powering domestic, non-power hydro dams, which would utilize smaller turbines. This potential growth in the U.S. and international market demand for small hydro turbines could offer greater opportunities for local and more energy-efficient manufacturing practices, both within the U.S. and for export.

Read more.

Advanced Scientific Analysis

The present and future silver cost component in crystalline silicon PV module manufacturing

Michael Redfield, Michael Wodzinski, and Frederick G. Goggin

Division of Economics and Business, Colorado School of Mines (CSM), Golden, Colorado; Strategic Energy Analysis Center, National Renewable Energy Laboratory (NREL), Golden, Colorado, USA.

ABSTRACT

The purpose of this paper is to determine how increased cell panel production might affect future silver demand and prices, as well as the impacts on total cell module manufacturing costs. A bottom-up estimation of the current and potential material intensity (grams of silver per watt) for silver anodized PV cell modules is presented. This estimation is based on recent R&D developments in silver anode technology. To evaluate the potential impact of increased cell manufacturing, there is new interest in shifting away from the traditionally higher material intensity approach of screen printing with silver paste to alternative metallization techniques, such as sintering, which saves economically less silver. To evaluate how PV’s changing demand for silver might affect future silver prices, and the impact in terms of manufacturing costs, separate scenarios of silver’s contribution to a PV cell manufacturing costs are compiled on the basis of projected changes in demand and prices as a result of changes in material intensity. The highest indications that an expansion of cell production from silicon PV to 200MW in 2015 to 500MW in 2016-2021 may lead to the current level of silver demand remaining stable. However, the current estimation of manufacturing costs for the two contrasting methods - silver screen printing and metal–copper–silver electroplating - are presented.

External Advisory Committee

Interest from Business Community

Tesla Flips the Switch on the Gigafactory

Batteries are the limiting factor for electric cars, but few automakers have made a similar commitment to produce them, choosing instead to let suppliers like LG Chem and Samsung shoulder the risk. In 2015, 88 percent of the global lithium ion cell manufacturing took place in China, Japan, and South Korea, according to a report by the Clean Energy Manufacturing Analysis Center.
Clean energy technologies are those that:

1. Produce energy with **fewer environmental impacts** than conventional technologies, or
2. Enable existing technologies to operate more efficiently, consuming fewer natural resources
3. Include **renewable energy**, cleaner non-renewable energy, and energy efficiency technologies
4. Apply to **electricity generation**, fuel production, and sustainable transportation
Consider the Whole Value Chain and Link to Location
Benchmarks of Global Clean Energy Manufacturing

Vision
• Provide annual assessment of global state of clean energy manufacturing for government and industry to inform energy policy and investment strategies and promote economic growth

Unique Contributions
• First-of-a-kind effort to isolate and quantify the economic impacts of the clean energy manufacturing sector
• Establishes a common framework and new methodologies for assessing the impacts of clean energy technology manufacturing across the supply chain
• Provides benchmark to track manufacturing as the clean energy revolution unfolds over time

Available at www.manufacturingcleanenergy.org/benchmark
Four Clean Energy Manufacturing Benchmarks

Key Questions

- How does clean energy technology manufacturing impact national economies?
- What are the economic opportunities across the manufacturing supply chain?
- What are the global dynamics of clean energy technology manufacturing?

Assess and Track Via Common Benchmarks (Baseline year: 2014)

- **Value Added**: Estimate of clean energy manufacturing contribution to national economies
- **Trade Flows**: Snapshot of trade activity among economies across the supply chain
- **Market Size**: Relative concentration of consumption of clean energy technologies
- **Manufacturing Capacity and Production**: Distribution of manufacturing activity and where growth may occur
Benchmark Report Evolution

1. Methodology Development
   - Develop benchmark framework and methodologies
   - Pilot methodologies with c-Si solar PV modules
   - Review/Refine Methodologies

2. Benchmark Analysis
   - Apply methodologies to four technologies (collect data, conduct benchmark analysis)
   - Review/Vet data, analysis, insights

3. Benchmark Report
   - Establish Outline/organizational structure of report
   - Review/Revise outline
   - Draft report
   - Review/Revise report
   - Publish Report and associated summary/outreach materials
Benchmark Report Focus and Framework

Value Chain for Clean Energy Technologies

<table>
<thead>
<tr>
<th>Development</th>
<th>Manufacturing</th>
<th>Installation/Construction</th>
<th>System Integration</th>
<th>Operation &amp; Maintenance</th>
</tr>
</thead>
</table>

Manufacturing Supply Chain Links

<table>
<thead>
<tr>
<th>Raw Materials</th>
<th>Processed Materials</th>
<th>Sub-Components</th>
<th>Clean Energy Technology End Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica, Silver</td>
<td>Polysilicon, Silver Paste, Glass</td>
<td>C-Si PV Wafer, C-Si PV Cell, Frame, Encapsulant</td>
<td>C-Si Solar PV Module</td>
</tr>
<tr>
<td>Iron, Neodymium, or Dysprosium Ores</td>
<td>Steel, Fiberglass, Carbon Fiber, Neodymium and Dysprosium Alloys</td>
<td>Permanent Magnets, Generators, Gear Assemblies, Steel Components</td>
<td>Wind Turbine Components: Blades, Tower, Nacelle</td>
</tr>
<tr>
<td>Lithium, Cobalt, Nickel, Graphite Ores</td>
<td>Cathode Materials, Anode Materials, Electrolytes</td>
<td>Separators, Housings, Metal Foils, Tabs</td>
<td>Light Duty Vehicle Li-ion Battery Cell</td>
</tr>
<tr>
<td>Gallium, Indium, Yttrium Ores</td>
<td>Sapphire Substrates, Trimethyl Gallium (TMG), Trimethylindium (TMI), YAG Phosphors</td>
<td>LED Chips</td>
<td>LED Package</td>
</tr>
</tbody>
</table>

**Bold** indicates intermediates included in benchmark analysis. Criteria for inclusion in supply chain include:

- Constrained resource
- Unique or enabling process or product
- Impact on overall cost
- Critical to quality
- Imported and exported globally.
Benchmark Report Economies

Criteria for inclusion include:

- Market size
- Manufacturing capacity across the supply chain
- Data availability.

Manufacturing Capacity (end product), 2014

Brazil
Canada
China
Germany
India
Japan
Malaysia
Mexico
South Korea
Taiwan
United Kingdom
United States
# Benchmark Methodologies and Data Sources

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Approach</th>
<th>Data Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value Added</strong></td>
<td>Value added is a key component of national gross domestic product (GDP). Using I-O data for relevant manufacturing industries, the revenues from technology cost analysis are used to estimate the value added of known inputs to that technology in 2014.</td>
<td>OECD STAN Input-Output (I-O) database; CEMAC/EERE/NREL clean energy technology manufacturing analysis</td>
</tr>
<tr>
<td><strong>Trade Flows</strong></td>
<td>Balance of trade (exports less imports) is another key component of national GDP. The 2014 value of trade flows are derived from imports and exports data using estimates of clean energy manufacturing contributions based on other published studies.</td>
<td>U.S. International Trade Commission; International Trade Centre; Industry-specific production and demand data (see below)</td>
</tr>
<tr>
<td><strong>Market Size</strong></td>
<td>Published industry-specific data are synthesized to estimate global market demand in 2014.</td>
<td>Bloomberg New Energy Finance; Navigant Consulting; Yole Développement; MAKE, etc.</td>
</tr>
<tr>
<td><strong>Manufacturing Capacity and Production</strong></td>
<td>Published industry-specific market data are synthesized to estimate manufacturing capacity and production in 2014.</td>
<td>Bloomberg New Energy Finance; Navigant Consulting; Yole Développement; MAKE, etc.</td>
</tr>
</tbody>
</table>

Finding: Total and Technology Mix of Value Added from Clean Energy Manufacturing Varies Significantly by Country

Manufacturing value added for c-Si PV modules, wind turbine components, LED packages, and LDV Li-ion battery cells is highest for China, Japan, Germany and the United States and lowest for the United Kingdom, Mexico, and Canada.
Finding: U.S. Hosts a Strong Clean Technology Manufacturing Base and Leads in Value Added Retained

Larger economies, with more extensive manufacturing supply chains, lower reliance on imported inputs, and higher prevailing wages tend to retain more value added from clean energy manufacturing than smaller economies.
Finding: Extensive Dynamic Trade Network Supports Demand across the Supply Chain

Manufacturing of clean energy technologies is a complex global enterprise, with extensive trade among economies to support the geographical distribution of production and demand across the links in the supply chain.

Interactive Trade Flow Charts
www.manufacturingcleanenergy.org/benchmark
Finding: Extensive Dynamic Trade Network Supports Demand across the Supply Chain

- **Wind Components**
  - Very little trade

- **C-Si PV**
  - Large trade with major players

- **Lithium Ion Battery Cells**
  - Dispersed trade network

- **LED Packages**
  - Dispersed trade network
Finding: Balance of Trade Varies across Supply Chain

Economies that are net importers of end products may be major exporters of upstream processed materials and subcomponents of those same technologies.

<table>
<thead>
<tr>
<th>Country</th>
<th>PV Module</th>
<th>PV Cell</th>
<th>Polysilicon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>-15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Canada</td>
<td>-305</td>
<td>-135</td>
<td>3</td>
</tr>
<tr>
<td>China</td>
<td>7,477</td>
<td>1,881</td>
<td>-2,019</td>
</tr>
<tr>
<td>Germany</td>
<td>-1,369</td>
<td>1,165</td>
<td>931</td>
</tr>
<tr>
<td>India</td>
<td>22</td>
<td>-466</td>
<td>-92</td>
</tr>
<tr>
<td>Japan</td>
<td>-6,255</td>
<td>-266</td>
<td>-932</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1,626</td>
<td>428</td>
<td>-38</td>
</tr>
<tr>
<td>Mexico</td>
<td>402</td>
<td>-547</td>
<td>0</td>
</tr>
<tr>
<td>South Korea</td>
<td>1,600</td>
<td>-422</td>
<td>884</td>
</tr>
<tr>
<td>Taiwan</td>
<td>917</td>
<td>3,335</td>
<td>-959</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>-1,184</td>
<td>-660</td>
<td>-143</td>
</tr>
<tr>
<td>United States</td>
<td>-3,939</td>
<td>-20</td>
<td>1,774</td>
</tr>
</tbody>
</table>

Balance of Trade
Finding: Production Not Always Co-located with Demand

Wind components are typically made in the same economies that have high demand, but manufacturing and demand for c-Si PV modules, LED chips, and LDV Li-ion battery cells are less coincident.

Production of wind turbine components and c-Si PV modules is more concentrated than production of LED chips and LDV Li-ion battery cells.
Finding: Manufacturing Capacity Underutilized in 2014

Across the four clean energy technologies evaluated, in 2014 there was generally an excess of manufacturing capacity, relative to global demand.

Across the 12 economies, average utilizations in 2014 were:
- 62% for wind turbine components
- 55% for c-Si PV modules,
- 41% for Li-ion cells
- 37% for LED chips.
• **Dynamic:** Clean energy technology manufacturing and trade reflect the dynamics of a high-growth decade within an increasingly complex set of policy environments.

• **Investment:** Manufacturing activity and investment in new manufacturing facilities respond to both domestic demand and export markets, but both are not required.

• **Location:** Location of manufacturing facilities varies by technology, depending on need for economies of scale, transportation requirements, investment incentives, access to supply chains, etc.

• **Demand:** Increasing deployment of technologies provides manufacturers with more stable demand, enables investment, and drives down prices through economies of scale.

• **Full Value Chain:** Other parts of the value chain—research, installation, operations—generate significant value in their own right.

• **Knowledge:** Deeper knowledge of the product supply chains and market volumes are needed to inform industry and government decisions.
Many Thanks for Expert Contribution and Review

• Benchmark Methodology and Report Development
  – Key Co-Authors: Debbie Sandor, Donald Chung, David Keyser, and Margaret Mann
  – CEMAC Benchmark Report Subcommittee
    • Tom Catania, Executive in Residence, ERB Institute, University of Michigan
    • Victoria Gunderson, International Trade Specialist, Department of Commerce
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    • Colorado State University
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    • Department of Commerce
    • International Trade Administration

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Thank you!