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Measures of International Manufacturing and Trade of Clean Energy Technologies

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Systems Analysis of Global Manufacturing Supply Chains for Innovation, Policy, and Market Applications

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Communication of Results

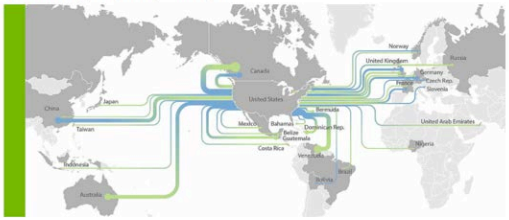
Manufacturing Clean Energy Blog

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 Kurup, 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 hydropower 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 Redlinger[1], Michael Woodhouse[2] & Roderick G. Eggert[1]

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ABSTRACT

The purpose of this paper is to determine how increased c-Si PV module production might affect future silver demand and prices, as well as the impacts on total c-Si module manufacturing costs. A bottom-up estimation of the current and potential material intensity (tonnes of silver per GW) for silver in c-Si PV cell fabrication is presented. Partly because of concerns about material intensity, and also because of the changing economics of manufacturing, there is some interest in shifting away from the traditionally higher material intensity approach of screen printing with silver paste to alternative metallization techniques, such as electroplating, which uses substantially less silver. To evaluate how PV's changing demand for silver might affect future silver prices, and the impact in terms of manufacturing costs, some scenarios of silver's contribution to c-Si PV cell manufacturing costs are compiled on the basis of projected changes in demand and price as a result of changes in material intensity. The analysis indicates that an expansion of c-Si production from 55GW/year to 250GW/year results in a 0.05–0.7¢/W increase in manufacturing costs because of higher silver prices. As an illustration of this, the current estimates of the manufacturing costs for the two contrasting methods – silver screen printing and nickel–copper–silver electroplating – are presented.

Reports for Policy and R&D Decision Makers

External Advisory Committee

Interest from Business Community

Bloomberg Technology — Markets | Tech | Pursuits | Politics | Opinion | Businessweek

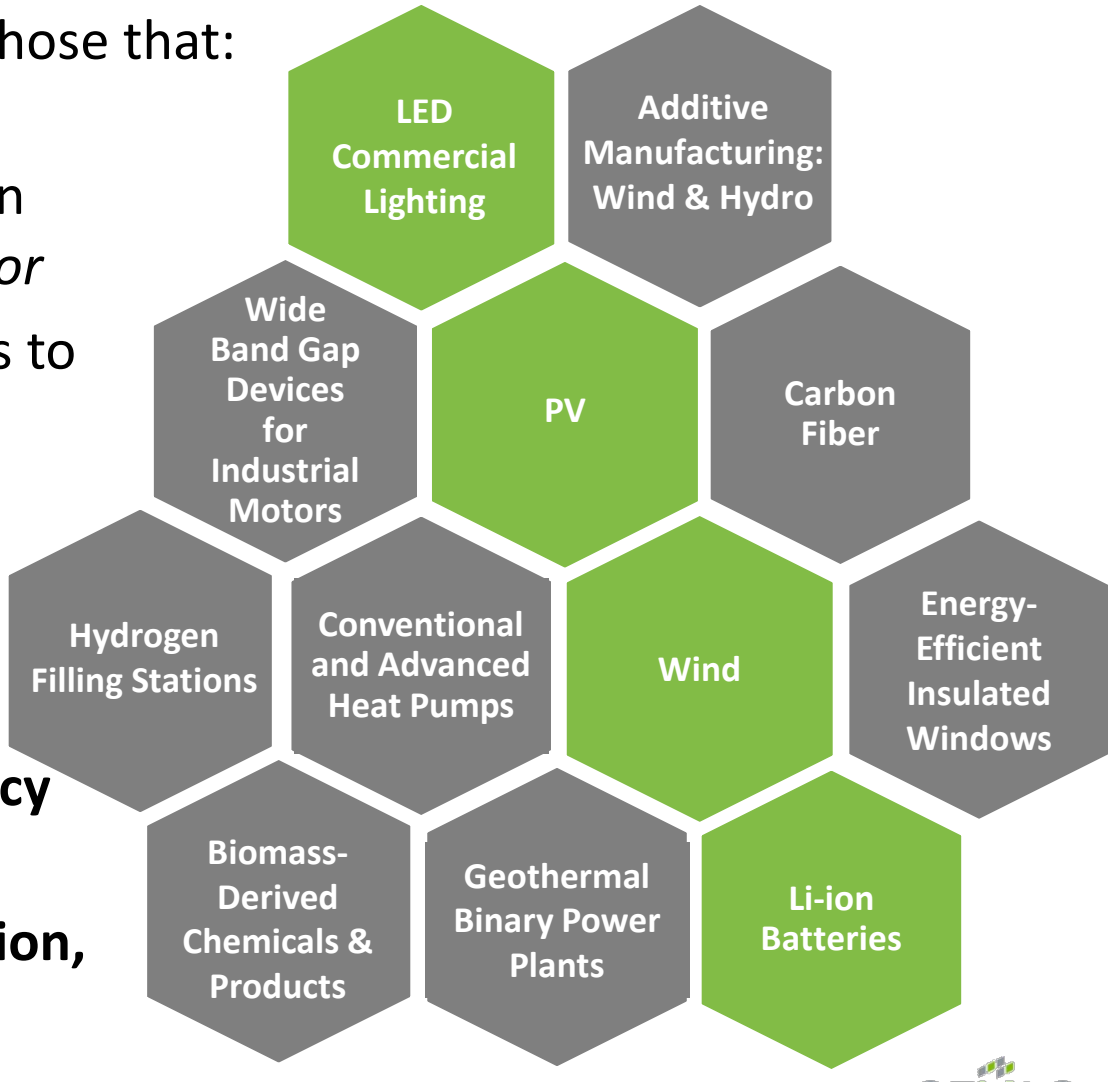
Tesla Flips the Switch on the Gigafactory

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. [9] 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.

Definition: Clean Energy Technologies

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**



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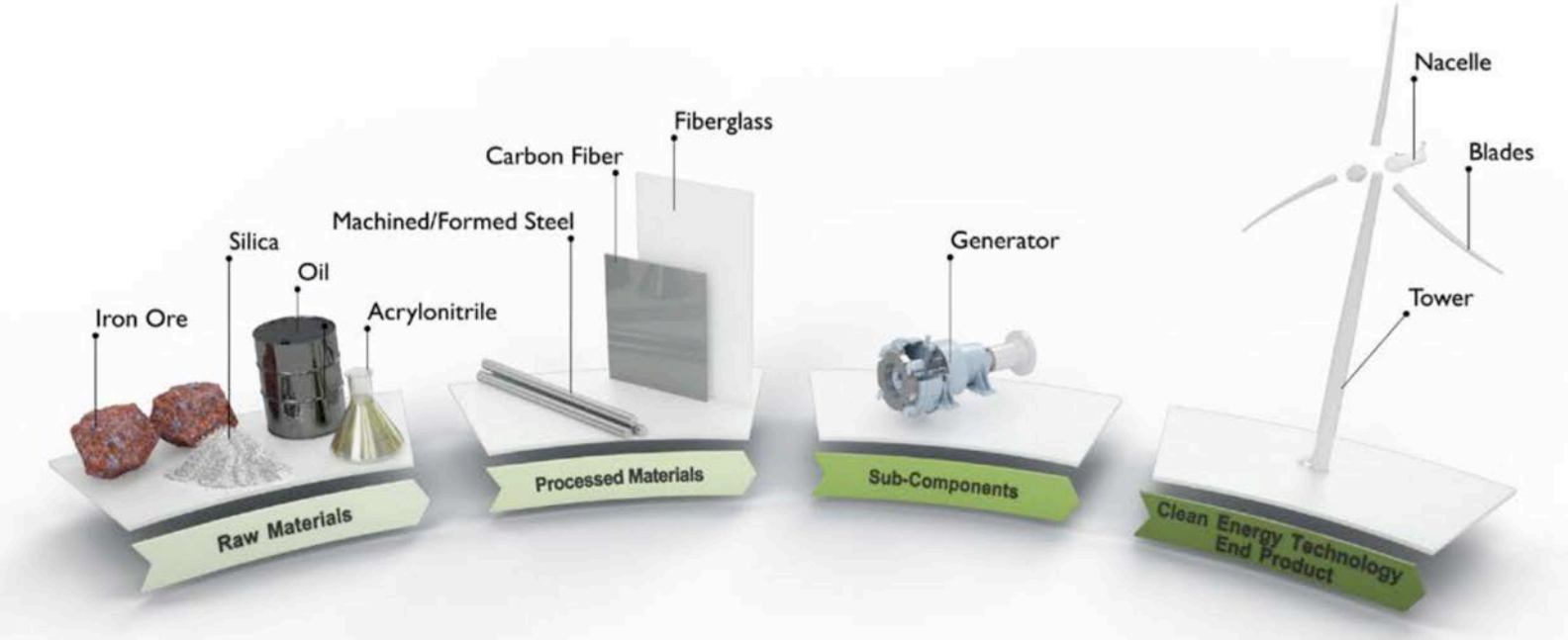
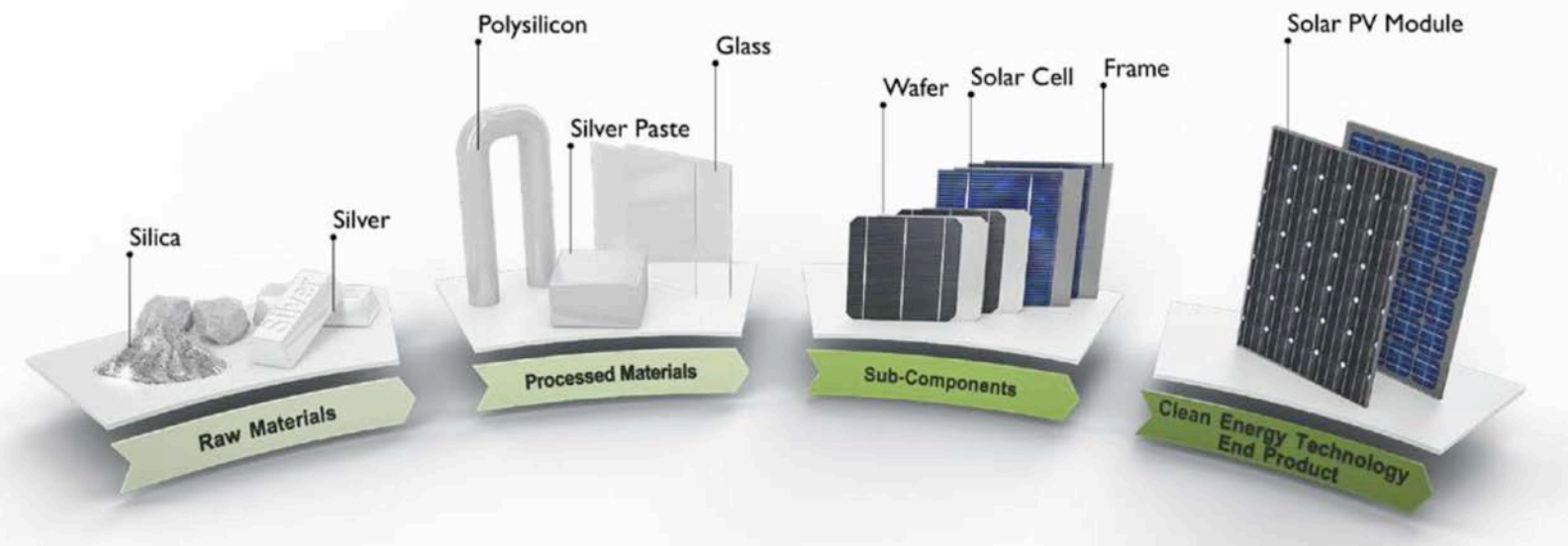
Consider the Whole Value Chain and Link to Location





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

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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

Development → **Manufacturing** → Installation/ Construction → System Integration → Operation & Maintenance

Manufacturing Supply Chain Links

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

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.

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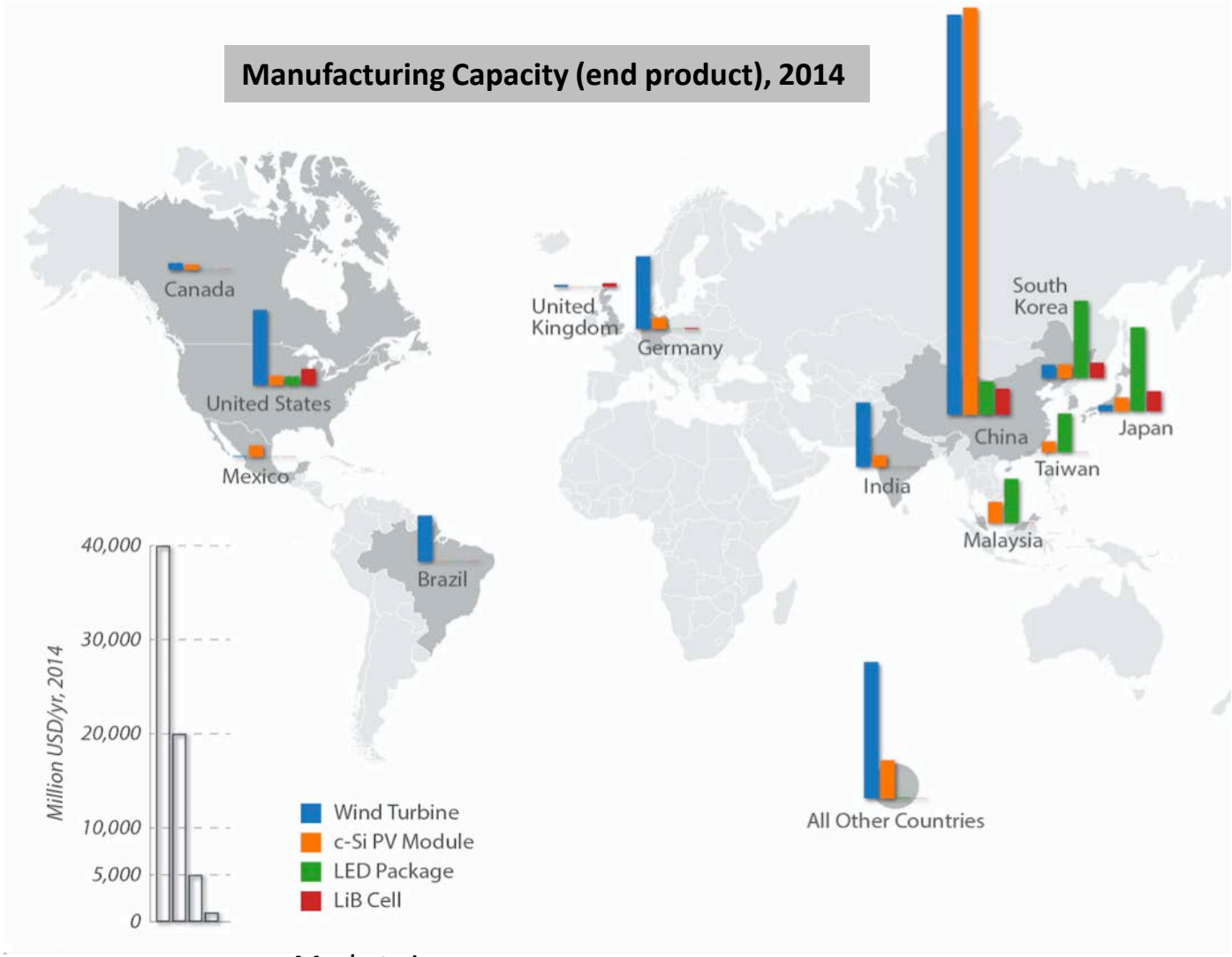
Benchmark Report Economies

Brazil
Canada
China
Germany
India
Japan
Malaysia
Mexico
South Korea
Taiwan
United Kingdom
United States



Criteria for inclusion include:

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

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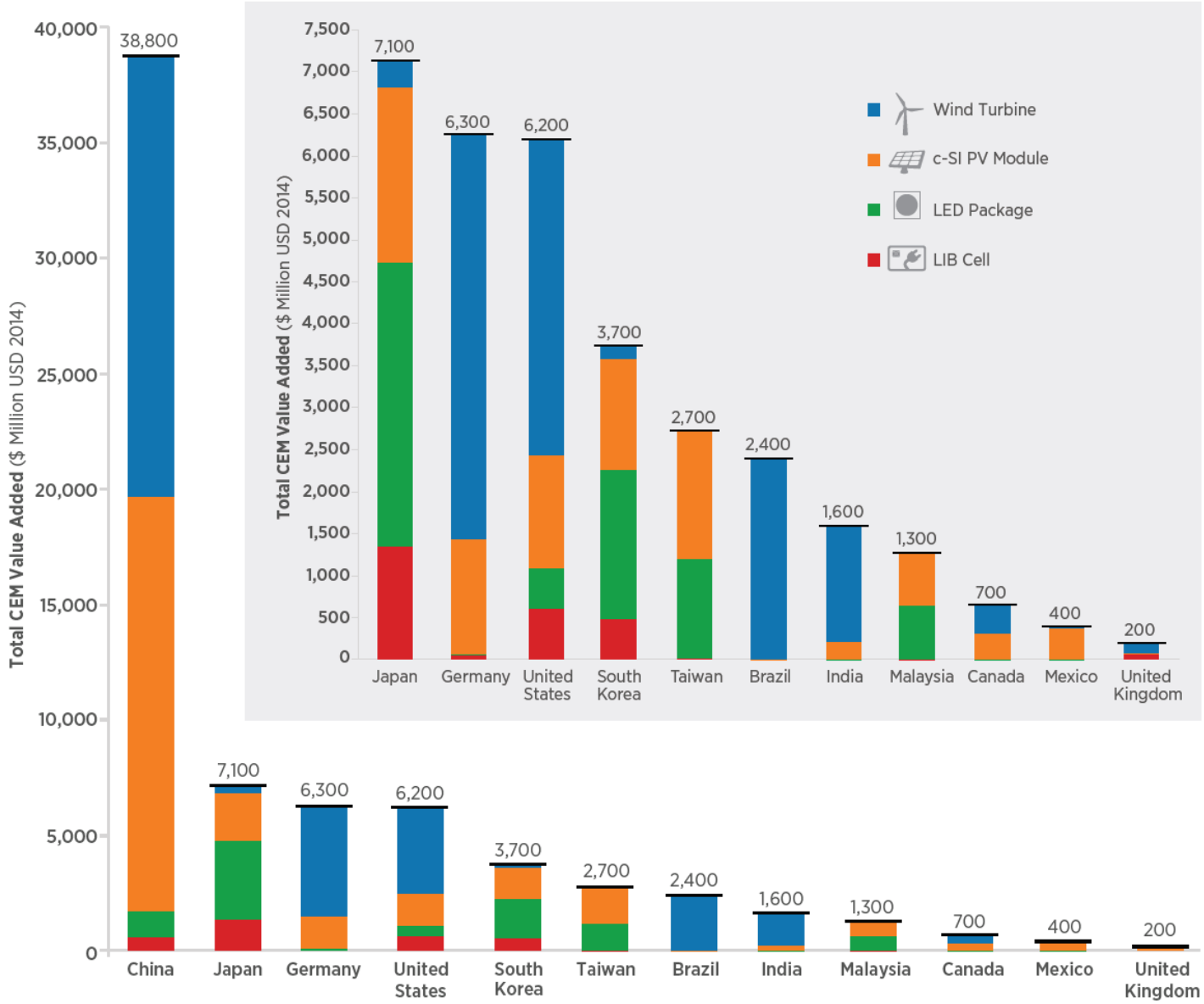
Benchmark Methodologies and Data Sources

Benchmark	Approach	Data Sources
Value Added	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.	OECD STAN Input-Output (I-O) database; CEMAC/EERE/NREL clean energy technology manufacturing analysis
Trade Flows	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.	U.S. International Trade Commission; International Trade Centre; Industry-specific production and demand data (see below)
Market Size	Published industry-specific data are synthesized to estimate global market demand in 2014.	Bloomberg New Energy Finance; Navigant Consulting; Yole Développement; MAKE, etc.
Manufacturing Capacity and Production	Published industry-specific market data are synthesized to estimate manufacturing capacity and production in 2014.	Bloomberg New Energy Finance; Navigant Consulting; Yole Développement; MAKE, etc.

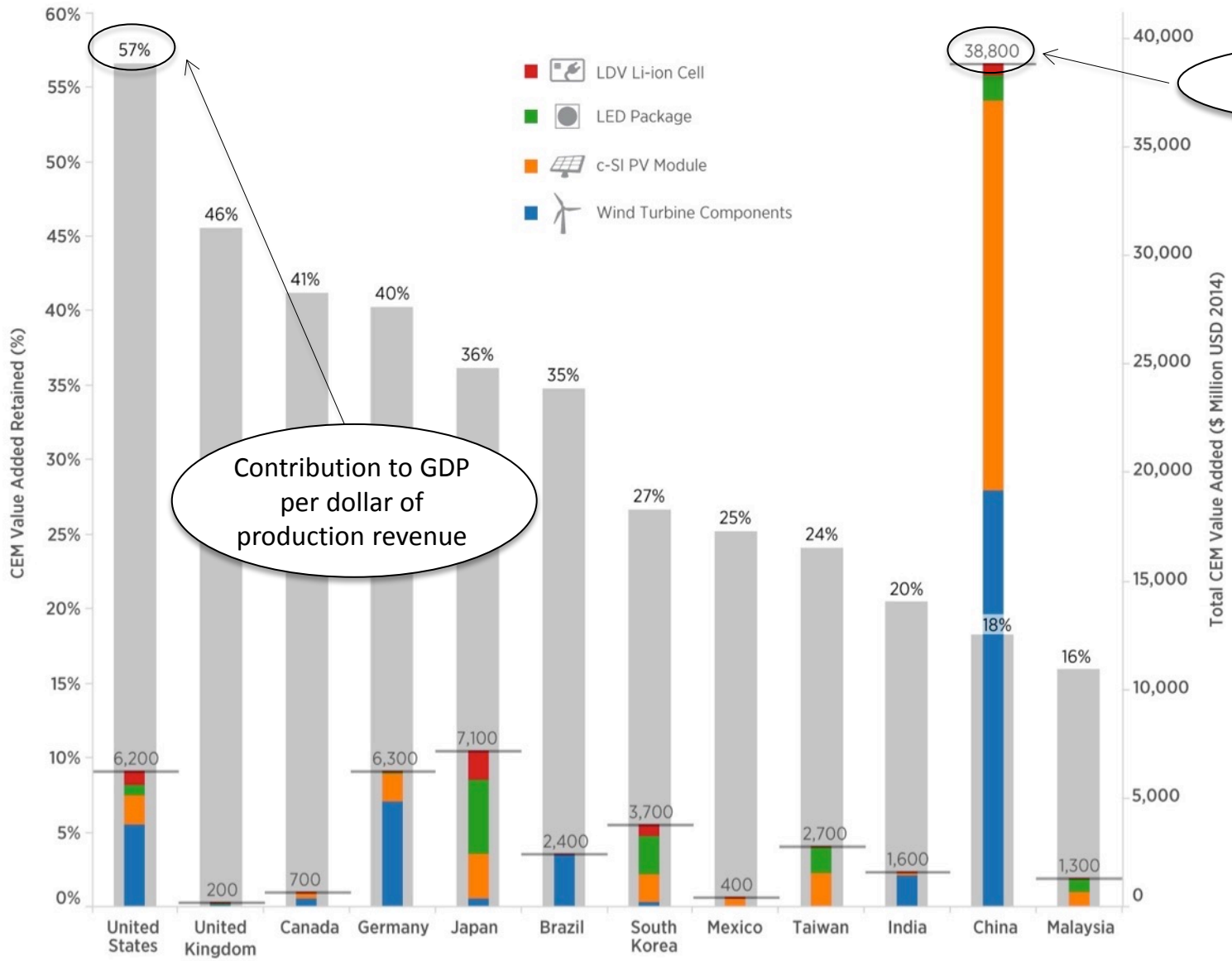
Benchmark methodologies are detailed in *CEMAC Clean Energy Manufacturing Benchmark Report: Framework and Methodologies* (2017) .

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

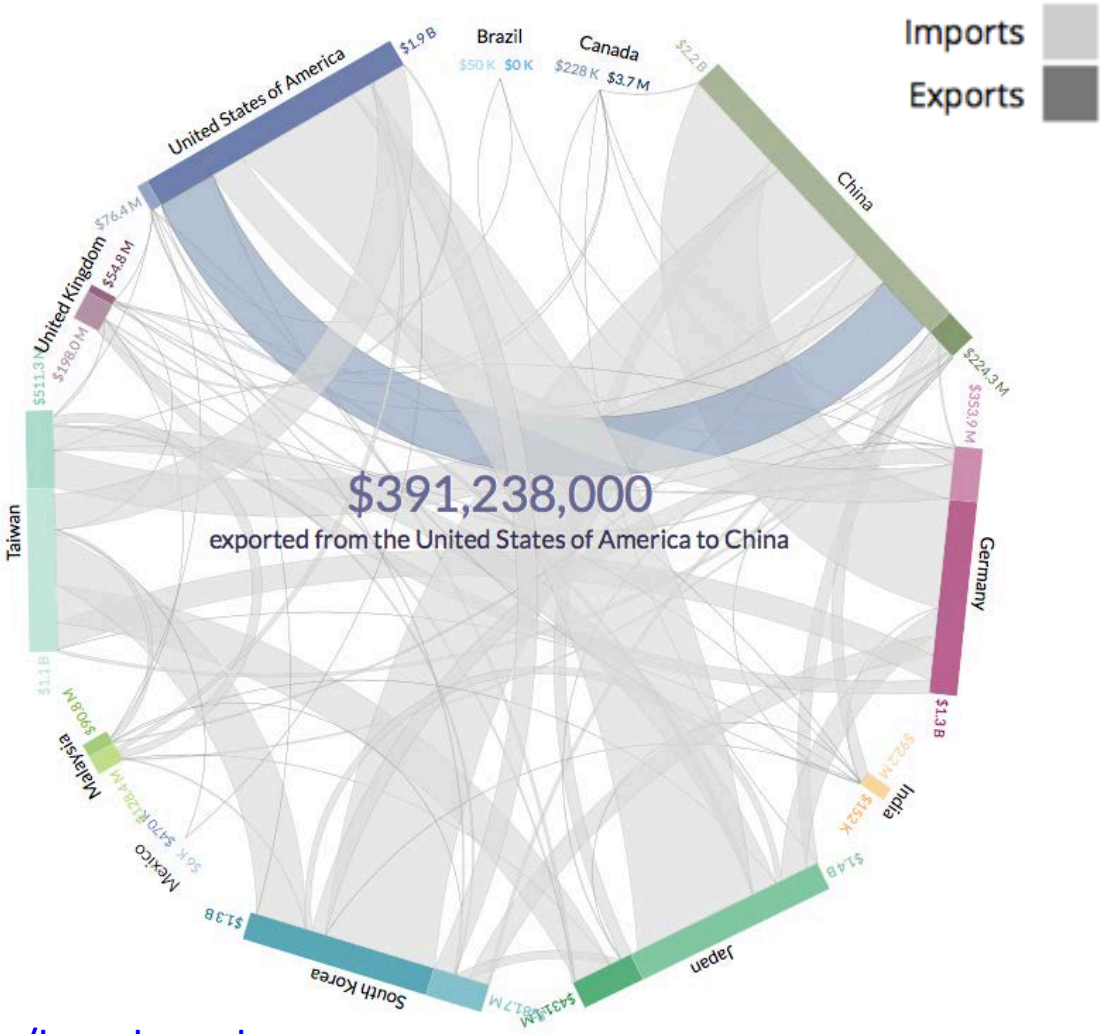


Larger economies, with more extensive manufacturing supply chains, lower reliance on imported inputs, and higher prevailing wages tend to retain more value added from clean energy manufacturing than smaller economies.

Finding: Extensive Dynamic Trade Network Supports Demand across the Supply Chain

PV Polysilicon, Global Summary
2014 USD

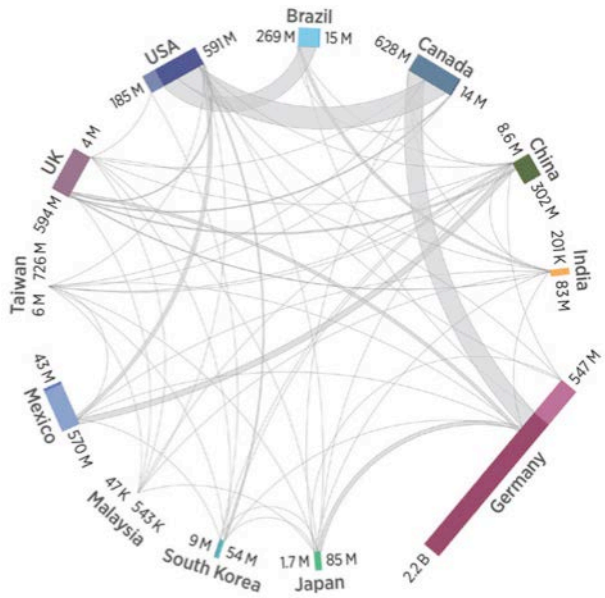
Manufacturing of clean energy technologies is a complex global enterprise, with extensive trade among economies to support the geographical distribution of production and demand across the links in the supply chain.

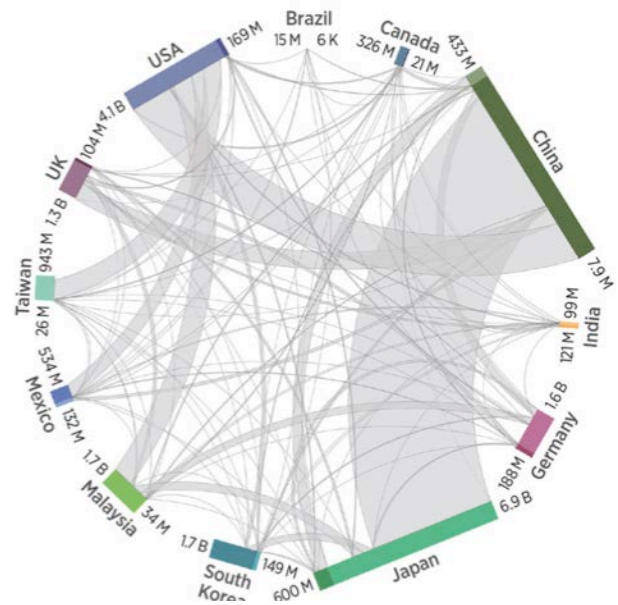


Interactive Trade Flow Charts
www.manufacturingcleanenergy.org/benchmark

Finding: Extensive Dynamic Trade Network Supports Demand across the Supply Chain

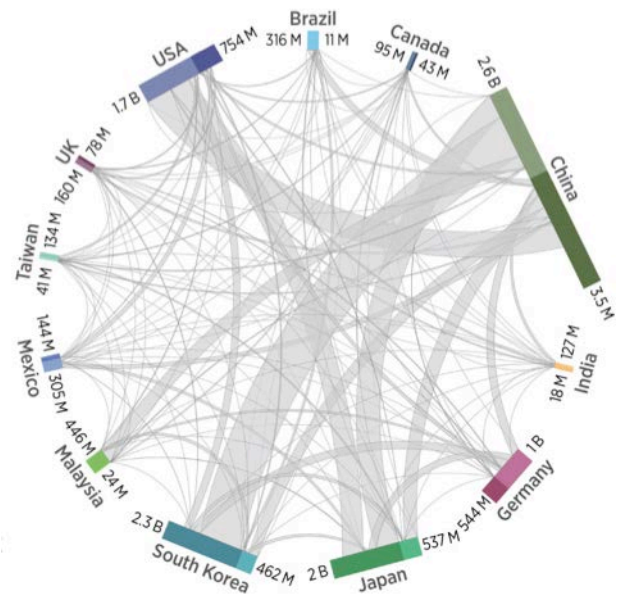
Wind Components
Very little trade

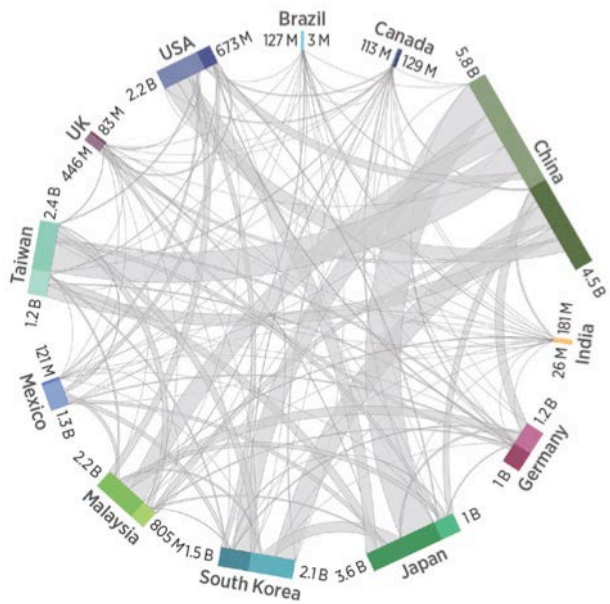




C-Si PV
Large trade with major players

Lithium Ion Battery Cells
Dispersed trade network

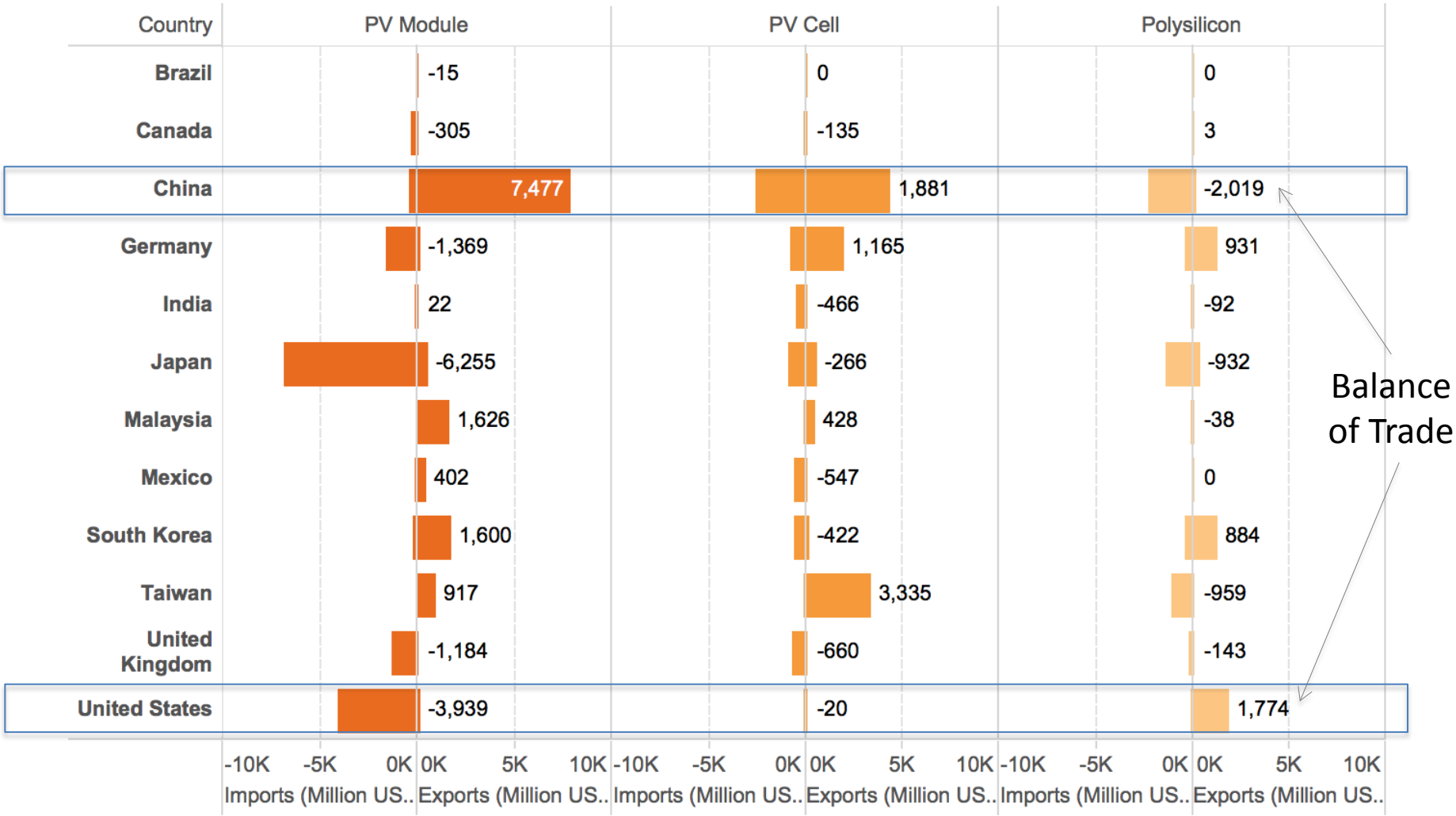




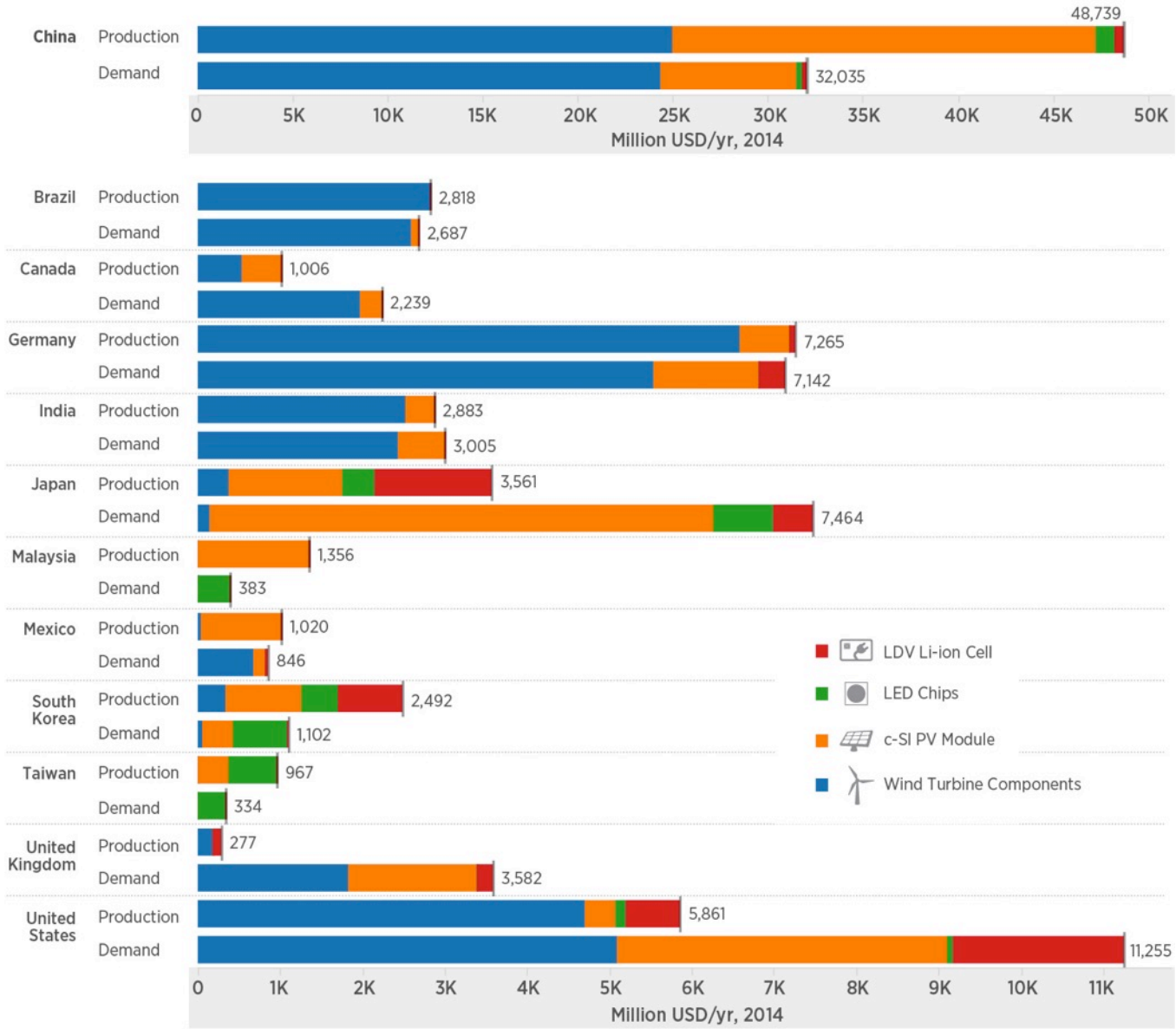
LED Packages
Dispersed trade network

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.



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.

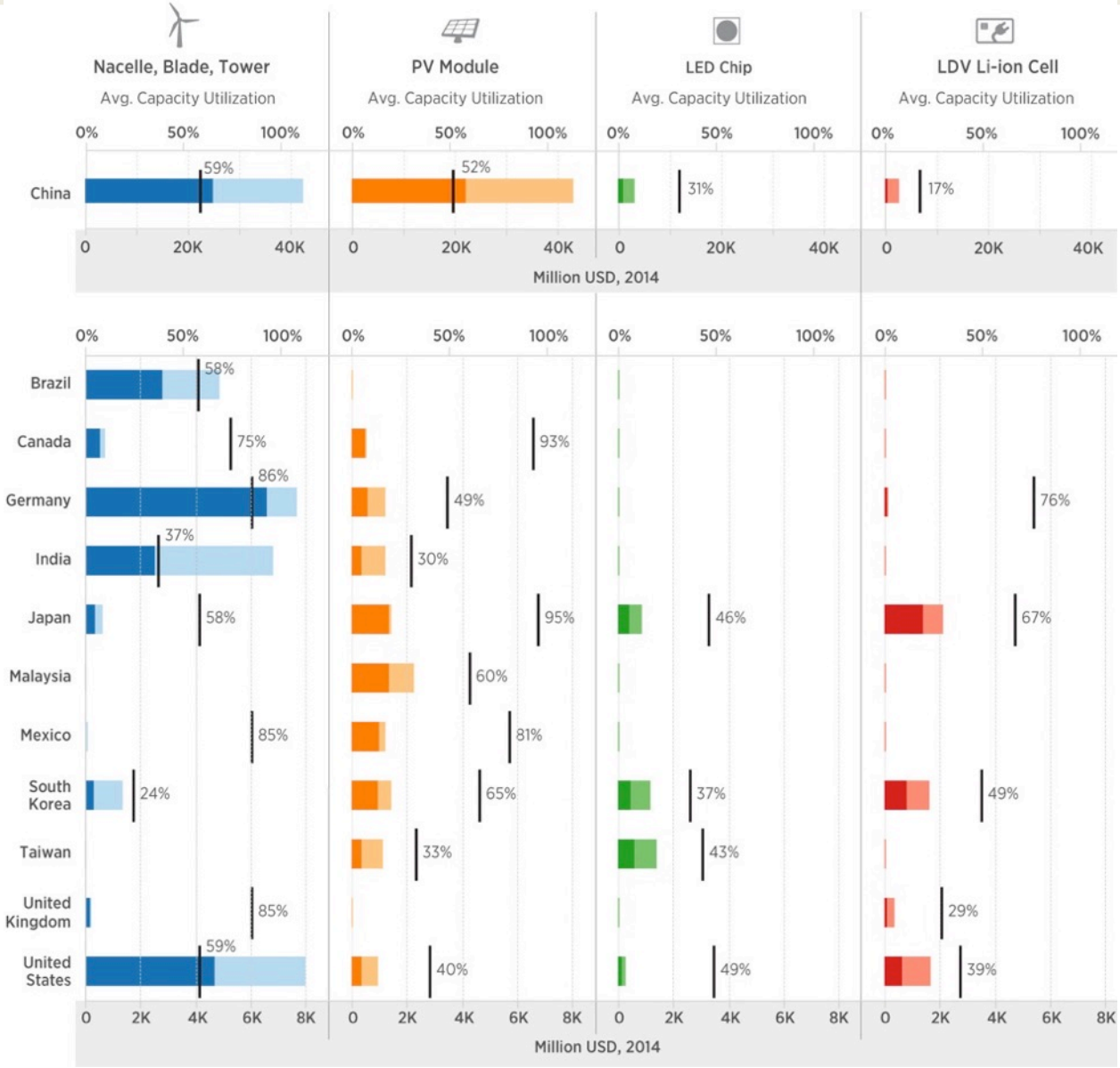
Production of wind turbine components and c-Si PV modules is more concentrated than production of LED chips and LDV Li-ion battery cells.

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.



Dark Bars = Production; Light Bars = Manufacturing Capacity; Lines = Capacity Utilization

Conclusions and Overall Findings

- **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.

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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
  - University Advisors
    - Colorado School of Mines
    - Colorado State University
  - Interagency Collaboration
    - Department of Commerce
    - International Trade Administration
- Data and Analysis Vetting and Report Review
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    - CEMAC Sponsors
    - EERE Technical Office Program Managers
  - JISEA/NREL Management

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Questions, Answers, and Discussion

Thank you!

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