Impact of IRA, IIJA, CHIPS, and Energy Act of 2020 on Clean Technologies

Deep Dive | Solar PV

APRIL 2023

Source: BCG analysis
**Solar PV | Executive summary**

- **IRA/IIJA provisions provide significant supply and demand-side support** to both accelerate domestic solar deployment and incentivize building a domestic US solar supply chain, which is highly concentrated in Asia.

- **IRA/IIJA provisions are expected to decrease US solar LCOE ~40% and increase US solar capacity deployed 30-40% through 2030** through a mix of domestic manufacturing credits and extended ITC/PTC incentives.

- Supply-side incentives are expected to make US-manufactured modules 25-40% cheaper for domestic projects than Asian imports due to manufacturing credits and ITC domestic content adders, driving demand for a US solar manufacturing base; while this may create some export opportunities, domestic demand is expected to outstrip domestic supply for the foreseeable future.

- However, **long-term competitiveness of US manufacturing will depend on US players building vertically integrated manufacturing base and rapidly reducing cost** through economies of scale, automation, and product and manufacturing innovations; enabling this will require low-cost financing for manufacturing facilities, workforce development programs, and support for advanced R&D.

- **Though the IRA/IIJA improve solar project financials, long-standing bottlenecks such as grid expansion, permitting, and interconnection backlogs must be addressed** to enable accelerated US solar market growth.

- **Moving forward, aligning supply-side interests of manufacturers with demand-side interests of developers** through guaranteed demand agreements, long-term contracts for developers to build upstream manufacturing capacity, and international partnerships for technology transfer by providing domestic market access is key to fully unlock the potential of the IRA provisions.

1. Total number of positions created through 2050; incremental new jobs calculated as the sum of all non-negative one-year differences in # job-years (e.g., 2021 job-years minus 2020 job-years gives 2021 new jobs); incremental new jobs added to sum from prior period for cumulative calculation.

Note: Numbers on the left are based on IEA’s Announced Pledges (APS) scenario summed up across all value chain segments from 2020-2050. Source: IEA; BCG Analysis.
Recent US policies (e.g., IRA, IIJA) have resulted in significant increases in projected size of domestic market, exports, and jobs within solar

**US domestic market**

US cumulative domestic market ('20-'30) increased from ~$590B to ~$830B after IRA/IIJA due to increased domestic deployments.

**US exports**

US cumulative exports ('20-'30) increased from $120B to $135B after IRA/IIJA, a smaller increase as IRA/IIJA mostly affect domestic manufacturing and deployment.

**US job creation**

New job creation in US solar industry ('20-'30) increased from ~340K to ~470K after IRA/IIJA primarily due to increased domestic manufacturing and deployments.

Note: All numbers based on IEA WEO STEPS scenario pre- and post-IRA based on change over timeframe from 2020-2030.

Source: BCG analysis.
Legislation impacts | IRA and IIJA support of solar expected to reduce levelized cost of energy and increase deployment up to 40% from pre-IRA levels

Demand-side incentives from the IRA include:

1. ITC: 6% base with 5x multiplier for wage and apprenticeship requirements
2. PTC: 1.5 ¢/kWh if wage and apprenticeship requirements are met
3. ITC & PTC: 10% bonus for domestic content + 10% bonus for plants in energy communities
4. ITC: Additional 20% for facilities in qualifying low-income communities

Demand-side incentives decrease LCOE by 40%...
Solar LCOE forecast ($/MWh)

- Cost without tax credit
- Cost with tax credit

... increasing 2030 capacity 30-40% from pre-IRA levels...
Solar capacity forecast (GW)

- 2020 Capacity
- 2030 Capacity pre-IRA
- 2030 Capacity post-IRA

...and decreasing unit cost up to ~5% due to added capacity

Incremental % change of unit cost in 2030 relative to 2022

1. Assumes 50% Investment tax credit
2. Business as usual: 2030 capacity projection pre-IRA based on IEA stated policy (STEPS) scenario
3. Capacity effect: incremental cost reduction due to added US capacity and additional global deployment (assumed 3x US increase)
4. Learning rate effect: incremental cost reduction due to de-risked commercialization (US moving early) and innovation (improved learning rates)

Note: 2030 cost projection do not account for inflation or subsidies. Source: IEA WEO 2021 and 2022; BCG Analysis
Legislation impacts  |  IRA provisions for solar are expected to make domestically manufactured modules ~25-40%¹ cheaper than imported modules

 IRA’s supply-side incentives span the solar value chain

 Made in US for domestic market:  
 US can produce modules domestically for 25-40%¹ less expensive than historical imports

 Made in US for exports:  
 IRA mfg. credits may not make US exports cost competitive with SEA-produced modules

| IRA provisions for solar are expected to make domestically manufactured modules ~25-40% cheaper than imported modules |
| Made in US for domestic market: US can produce modules domestically for 25-40% less expensive than historical imports |
| Made in US for exports: IRA mfg. credits may not make US exports cost competitive with SEA-produced modules |

| 1. Range of cost decline depends on steps produced in the U.S., with favorable end of range assuming all domestic mfg incentives are captured across manufacturing steps and full tax incentives are passed onto the developer; 2. 30%; ITC can range from 6% to 70% - 6% base, 30% if prevailing wages and apprenticeship are met, 10% domestic content bonus, 10% energy community bonus, 20% low-income bonus; 3. Value shown assumes only final assembly in the U.S; 4. 14.75%; tariffs exempted for 24-months from June 2022 on solar modules imported from Cambodia, Malaysia, Thailand, and Vietnam; 5. Assumption of shipping costs is conservative; 6. Based on historical module spot prices, does not account for forward-looking cost declines. |

Note: The cost advantage due to IRA incentives may not be durable as policies on tariffs shift, logistics costs change, and incentives expire; Source: InfoLink, BCG Analysis
Maintaining competitiveness | However, US long-term competitiveness will depend on reducing costs through manufacturing innovation scale

Domestic demand is expected to be 1.5-6x greater than announced supply

<table>
<thead>
<tr>
<th>Announced</th>
<th>Idle</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polysilicon</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Wafers</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Cells</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Modules</td>
<td>70</td>
<td></td>
</tr>
</tbody>
</table>

2021 US annual installations

2030 post-IRA US annual installations

Absent scale, US cost advantage will dissipate post-2033

- China-produced module cost in 2033: $0.15
- US-produced module cost in 2033: $0.22
- Post-IRA incentives, US forecast to lose cost advantage by 2033 absent scale and innovation

Key avenues to increase cost competitiveness:

- Rapidly expand domestic capacity to capture economies of scale
- Deploy manufacturing automation to reduce labor costs
- Integrate supply chains vertically to increase synergies, lower shipping costs, and reduce reliance on imports
- Innovate on product and manufacturing to improve overall efficiency

1. NREL Fall 2022 Solar Industry Update, solar installations are based on IEA’s data from the World Energy Outlook 2022 under STEPS for post-IRA capacities. Source: IRA, DOE PV Supply Chain Review, NREL Fall 2022 Solar Industry Update, SEIA, Credit Suisse, BCG analysis
Realizing benefits | Further, interconnection reform, grid expansion, and permitting reform is required to fully unlock demand-side incentives

- Solar interconnection queues in the US have grown faster than other renewables (e.g., ~9x faster than onshore wind)

- Grid expansion and upgrades are needed to ensure grid reliability given increased variability from renewable generation

- Long transmission permitting process hinders infrastructure expansion due to limited clarity around permitting timelines, misaligned interests of stakeholders, and stringent environmental standards

Deep dive into the scale of the transmission challenge for solar in the US

- Steady growth in interconnection queues for solar...
  - Total Capacity in Queues (GW)

- ... and processing times of 4+ years from request to operation...
  - Duration from IR to COD (Months)\(^1\)

- ... lead to low and steadily decreasing completion rates
  - Project completion rate (%)\(^2\)

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1. IR = interconnection request; COD = commercial operation date. 2. Completion percentage includes projects that have been withdrawn for reasons other than transmission bottlenecks. Source: Lawrence Berkeley National Laboratory (Queued up), IEA WEO 2022, BCG analysis
Pre-legislation challenges | Several areas inhibited domestic solar manufacturing and deployment

1. Antidumping and Countervailing Duties
2. Uyghur Forced Labor Prevention Act

Source: BCG Analysis
## Remaining challenges | Additional policy is needed to fully unlock legislation benefits and maintain US long-term competitive advantage

### Pre-legislation priority challenges

<table>
<thead>
<tr>
<th>Polysilicon production</th>
<th>Wafer, cell, and module manufacturing</th>
<th>Project Development, EPC, and O&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Uncertainty in demand for domestic polysilicon and high production costs</td>
<td>2. Bottlenecks in setting up domestic manufacturing base (e.g., equipment costs)</td>
<td>4. Lack of solar-trained skilled workforce (engineers, scientists) for manufacturing facilities</td>
</tr>
<tr>
<td>3. US operational cost disadvantage due to high labor and manufacturing costs</td>
<td></td>
<td>5. Long interconnection queues and unclear cost-allocation for required grid infrastructure upgrades</td>
</tr>
</tbody>
</table>

### Changes from recent legislation (IRA, IIJA, CHIPS, and EA 2020)

- 45X advanced manufacturing tax credits for polysilicon ($3/kg)
- 48C investment tax credit of up to 30%
- IIJA $750M Advanced Energy Manufacturing and Recycling Grant Program
- 45X advanced manufacturing tax credits for wafer ($12/m²), cell (4¢/W), and modules (7¢/W)
- 48C investment tax credit of up to 30%

### Remaining areas to target with future policies

- Facilitate polysilicon export to international wafer manufacturers and provide low-cost electricity to domestic polysilicon plants
- Re-assess section 301 tariffs and stringent certifications for PV manufacturing equipment, and provide low-cost land
- De-risk investment to build integrated wafer, cell, and module manufacturing facilities and fund research into manufacturing automation to achieve scale
- Fund and establish solar-focused science and engineering training programs, while maintaining a supportive immigration policy
- Reform interconnection processes and enable collaboration between governments, transmission providers, and developers

### Priority areas

1. Antidumping and Countervailing Duties
2. Uyghur Forced Labor Prevention Act

Source: IRA; IIJA; DOE; IEA; BCG Analysis
Summary | IRA provides significant support for domestic solar activity, but further action needs to be taken to boost US competitiveness

Key levers that will enable the US to win the solar market

- **Grid expansion**: Additional support for transmission grid development to successfully connect solar to existing grid network.
- **Permitting reform**: Permitting reform for transmission infrastructure, manufacturing facilities, and solar projects will enable rapid solar deployment domestically.
- **Interconnection backlog**: Support to reduce interconnection timeline and cost to developers will ensure solar deployment is effective and efficient.
- **Workforce development**: Funding to setup workforce development programs is essential to ensure availability of skilled labor (scientists, engineers) for upstream manufacturing.

Source: BCG Analysis
Backup | **New legislation provides incentives for facilities and production of PV Solar (I/III)**

<table>
<thead>
<tr>
<th>Provision</th>
<th>Summary</th>
<th>Type</th>
<th>Total investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRA Section 13101: Renewable Energy Production Tax Credit&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Extension and modification of PTC for electricity for solar. Base credit of 0.3 cents/kWh and 1.5 cents/kWh if Wage/Apprenticeship requirements are met. Applies to facilities after 2024 and phases down in 2032</td>
<td>Production Tax Credit (PTC)</td>
<td>$51B</td>
</tr>
<tr>
<td>IRA Section 13102: Energy Investment Tax Credit&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Extension and modification of the Investment Tax Credit to expand clean energy manufacturing. 30% ITC and 10% bonus if domestic manufacturing requirements are met. Applies to facilities after 2024 and phases down in 2032</td>
<td>Investment Tax Credit (ITC)</td>
<td>$13.96B</td>
</tr>
<tr>
<td>IRA Section 13103: Low-Income Solar and Wind Investment Tax Credit&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Increase in energy credit for facilities placed in service in connection with low-income communities. 10% bonus for projects located in low-income communities</td>
<td>Investment Tax Credit (ITC)</td>
<td>-</td>
</tr>
<tr>
<td>IRA Section 13701: Clean Electricity Production Credit&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Intended to replace 13101. Tax credit for domestically produced, zero emissions electricity. Facility must be placed into service after December 31&lt;sup&gt;st&lt;/sup&gt;, 2024. Technology agnostic</td>
<td>Production Tax Credit (PTC)</td>
<td>$11.2B</td>
</tr>
<tr>
<td>IRA Section 13702: Clean Electricity Investment Credit&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Intended to replace 13102. Tax credit for domestically produced, zero emissions electricity. Facility must be placed into service after December 31, 2024. Technology agnostic</td>
<td>Investment Tax Credit (ITC)</td>
<td>$50.9B</td>
</tr>
</tbody>
</table>

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1. CTVC IRA Tracker  
2. RMI  
3. Department of Energy FY2023 Budget  
4. US Senate  

Source: BCG Analysis
### New legislation provides incentives for facilities and production of PV Solar (II/III)

<table>
<thead>
<tr>
<th>Provision</th>
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<th>Type</th>
<th>Total investment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IRA Section 13302:</strong> Residential Clean Electricity Tax Credit</td>
<td>30% residential tax credit for residential solar</td>
<td>Residential</td>
<td>$22B</td>
</tr>
<tr>
<td><strong>IRA Section 13501: 48C Advanced Energy Manufacturing Project Tax Credit</strong></td>
<td>Extension of the advanced energy project credit. Base rate of 6% and 30% tax credit if wage and apprentice requirements are satisfied</td>
<td>Manufacturing Tax Credit</td>
<td>$10B</td>
</tr>
<tr>
<td><strong>IRA Section 13502: 45X Wind, Solar, and Battery Manufacturing Production Tax Credit</strong></td>
<td>Advanced Manufacturing Tax Credit, is a credit for manufacturers of eligible components produced within the United States. Tax credits include polysilicon ($3/kg), wafer ($12/m²), cell (4¢/W), and modules (7¢/W)</td>
<td>Manufacturing Tax Credit</td>
<td>$30.6B</td>
</tr>
<tr>
<td><strong>IIJA Section 40541: Allocation For Public Schools</strong></td>
<td>Grants for energy efficiency improvements and renewable energy improvements at public school facilities</td>
<td>Grant</td>
<td>$500M</td>
</tr>
<tr>
<td><strong>IIJA Section 40209: Advanced Energy Manufacturing and Recycling Grant Program</strong></td>
<td>Establishes a grant program (FY2022-2026) for facilities that produce or recycle advanced energy technologies (wind, solar, storage, fuel cells, microturbines, geothermal, hydrothermal, and electric grid modernization)</td>
<td>Grant</td>
<td>$750M</td>
</tr>
</tbody>
</table>

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Source: BCG Analysis
## New legislation provides incentives for facilities and production of PV Solar (III/III)

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</tr>
</thead>
<tbody>
<tr>
<td>11 IIJA Generally: Relevant solar funding not directly allocated</td>
<td>Unspecific funding for power infrastructure. For other fuels and technology infrastructure</td>
<td>Grant</td>
<td>$14B</td>
</tr>
<tr>
<td>12 IIJA Section 40341: Clean Energy Demonstration Program On Current and Former Mine Land$^3$</td>
<td>Funding for solar demonstration projects on current and previous mines. Allocated evenly through FY2022-2026</td>
<td>Grant</td>
<td>$500M</td>
</tr>
<tr>
<td>13 CHIPS Section 10771$^2$</td>
<td>$800M to carry out renewable power research, development, and demonstration activities. $1B for electric grid modernization and security research, development, and demonstration activities</td>
<td>Grant</td>
<td>$1.8B</td>
</tr>
<tr>
<td>14 CHIPS Section 10622: Regional Clean Energy Innovation Program$^2$</td>
<td>Authorizes a Regional Clean Energy Innovation Program at DOE to establish partnerships that promote the economic development of diverse geographic areas of the US by supporting clean energy innovation</td>
<td>Grant</td>
<td>$250M</td>
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<tr>
<td>15 CHIPS Section 10771: Advanced Research Projects Agency—Energy$^2$</td>
<td>Allocates funding to Department of Energy research, development, and demonstration activities (ARPA-E)</td>
<td>Grant</td>
<td>$1.2B</td>
</tr>
</tbody>
</table>

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4. US Senate
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