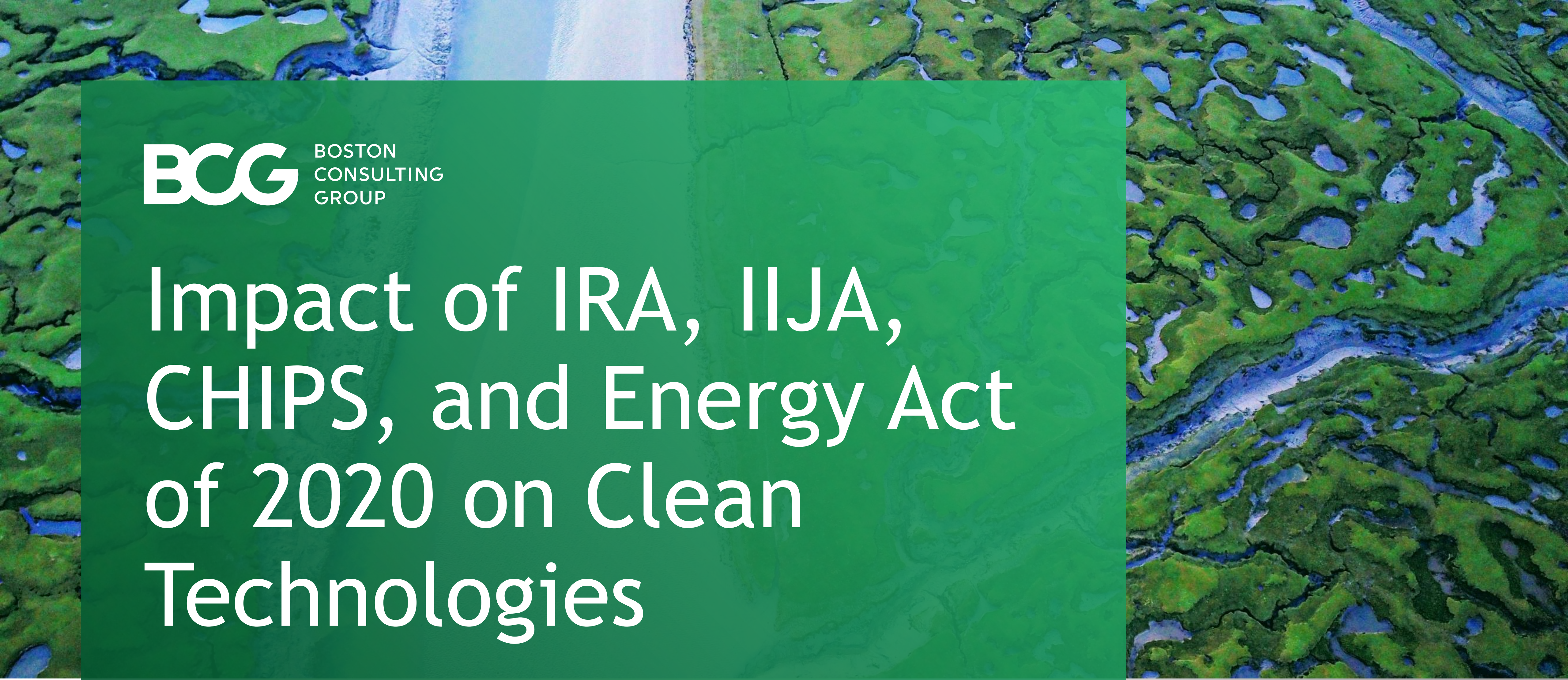

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Impact of IRA, IIJA, CHIPS, and Energy Act of 2020 on Clean Technologies

Cross-technology Summary

APRIL 2023

Background | Objectives and context of this work

Objective

- Explore impacts of recent legislation[1] on U.S. opportunity and remaining challenges for emerging clean technology deployment

Stakeholders involved

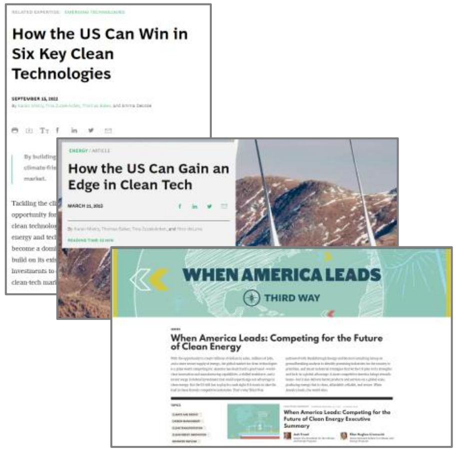
- Analysis was commissioned by Breakthrough Energy and Third Way, with input from stakeholders across the public and private sectors

Breakthrough Energy

THIRD WAY

Related publications

- BCG report | How the US Can Win in Six Key Clean Technologies
- BCG report | How the US Can Gain an Edge in Clean Tech
- Third Way publication | When America Leads: Competing for the Future of Clean Energy



1. Legislation assessed here includes Inflation Reduction Act (IRA), Infrastructure Investment and Jobs Act, CHIPS and Science Act, and the Energy Act of 2020
Source: BCG analysis

Executive summary

- The IRA and IIJA are the largest federal investments in climate - a historic financial commitment that will accelerate progress toward the U.S. decarbonization objectives, support energy security, help insulate the U.S. from energy price shocks, and position the U.S. to be a leader in the future global clean tech economy

- The combined legislation provides ~$470B in new energy and climate funding and will stimulate ~$1T in private investment to reduce the green premium, build domestic supply chains, and accelerate deployment to achieve economies of scale and further drive down long-term costs for clean technologies from energy to transportation

- While the IRA/IIJA significantly improved clean tech economics, the U.S. must take actions to address additional non-cost barriers which could stifle rapid deployment of these technologies and prevent the U.S. from capturing full upside potential, e.g.:
  - Reform obstructive permitting and regulations that can add years to development timelines, increase risk and financing costs, and slow both private and public investment
  - Invest in enabling infrastructure (e.g., electric grid, pipelines, shipping vessels) necessary to support rapid domestic deployment at scale, which is putting pressure on aging assets that have suffered from decades of underinvestment
  - Support the development of new supply chains (e.g., lithium from geothermal brine) to prevent a scarcity of production inputs
  - Enhance workforce programs to fill the 900k new jobs[1] created by these industries
  - Expand resources for early demonstration and commercialization projects, which are necessary to de-risk several nascent technologies and attract private investment in order to scale
  - Clarify the implementation of IRA provisions (e.g., domestic content requirements) with expeditious and transparent rulemaking to relieve the near-term uncertainty hampering private investment

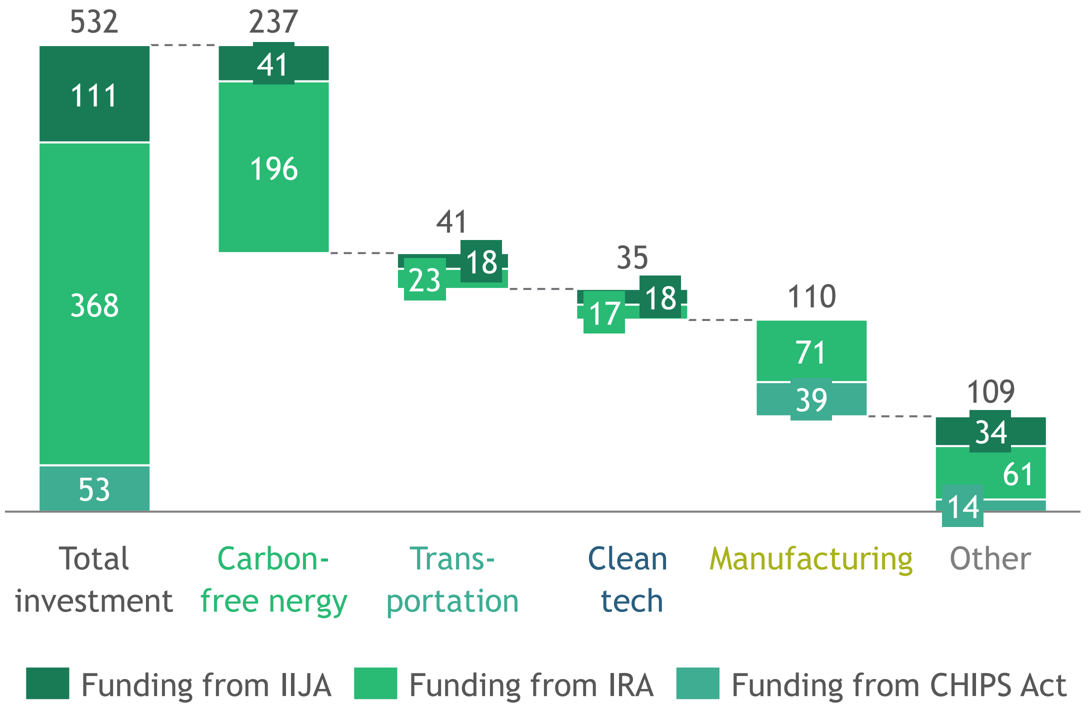
- Addressing such non-cost barriers will not only help unlock the economic and climate benefits of the IRA/IIJA, but also put the U.S. on a pathway to cost parity with existing technologies and cultivate long-term, durable competitive advantages, firmly establishing itself as a global leader in the clean economy

1. Represents the net job change. The total jobs created is 6.5M, which is referenced on slide 11, but will be offset by lost jobs in other sectors.
Source: IEA, BCG Analysis

The IRA[1] and IIJA[2] include over $470B in new climate, clean energy, and manufacturing incentives, supplemented by over $50B from the CHIPS[3] Act

Not Exhaustive

Breakdown of funding by category ($B)



Key incentives

Carbon-free energy	• Tax credits for investments in solar & storage, wind & nuclear energy, and transmission interconnects related to clean energy projects • Funding for energy efficiency
Transportation	• Tax incentive for purchase of electric vehicles • Funding for EV charging infrastructure
Clean tech	• Carbon capture tax credit for point source capture and direct air capture (DAC) • Tax credit for production of clean hydrogen • Funding for hydrogen and DAC hubs • Funding for sustainable aviation fuels (SAF)
Manufacturing	• Funding for advanced manufacturing production • Investment for advanced industrial facilities • Incentives to construct or modernize US fabs
Other	• Agriculture initiatives • Methane emissions charge (revenue generating) • Resilience investments (e.g., rural area dev.) • Greenhouse gas reduction fund • R&D funding under CHIPS act to invest in domestic centers & capabilities

1. Inflation Reduction Act 2. Infrastructure Investment and Jobs Act 3. Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act
Note: Focus of analysis has been concentrated on IRA/IIJA in these materials
Source: EPA, CBO, BCG Analysis

Accelerated clean tech deployment will spur unprecedented private investment in climate – up to $880B or an annual rate of up to $210B

Annualization of investments[1]

$0.8-1.6T in total investment

- Expected total investment catalyzed by federal funding, including $320-880B in private investment

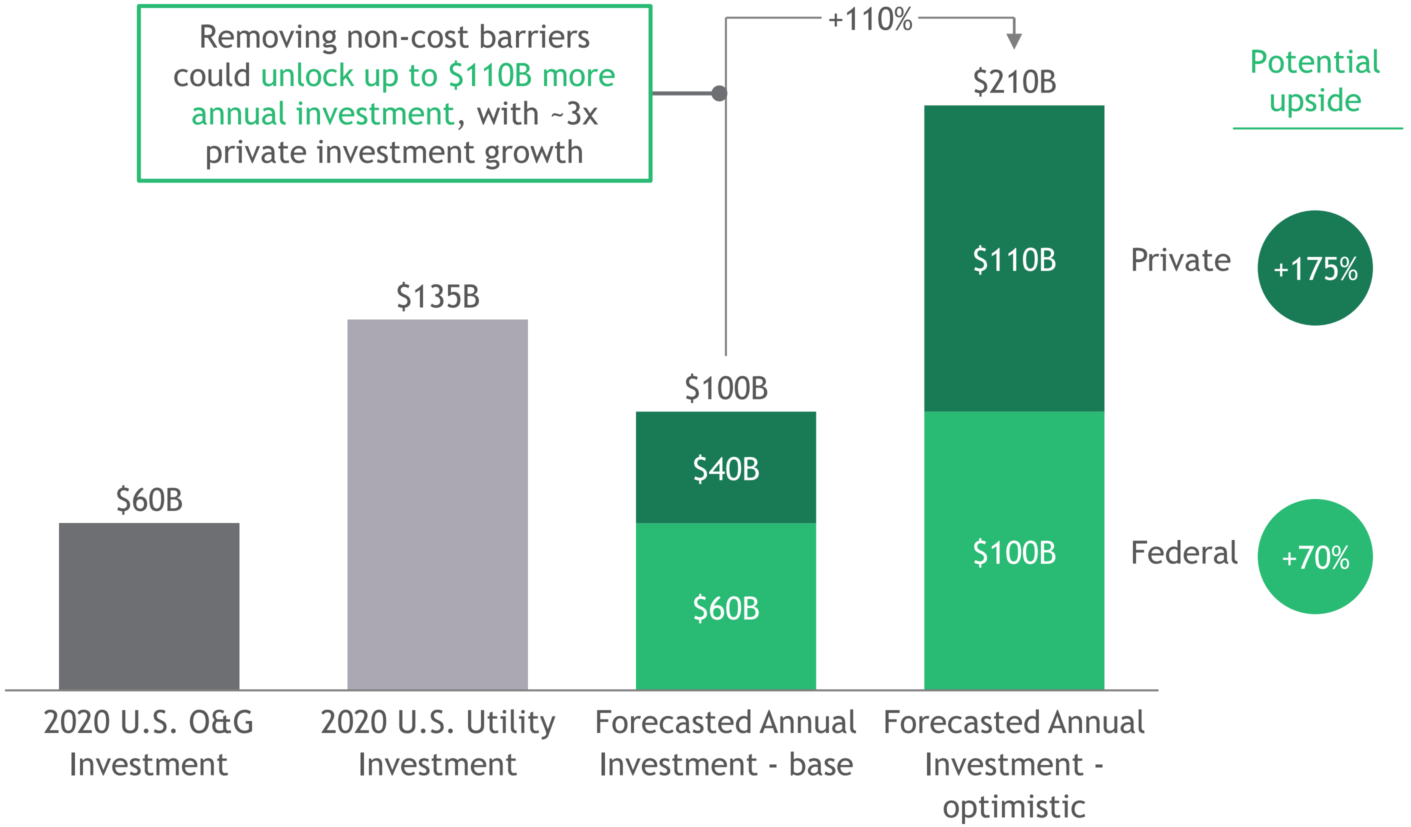
Over 8 years

- Estimates assume investment occurs between enactment and 2030

$210B annually

- Combined annual rate of investment catalyzed by federal funding

Annualized rate of investment generated by IRA & IIJA exceeds recent annual spending by U.S. utility & O&G industries

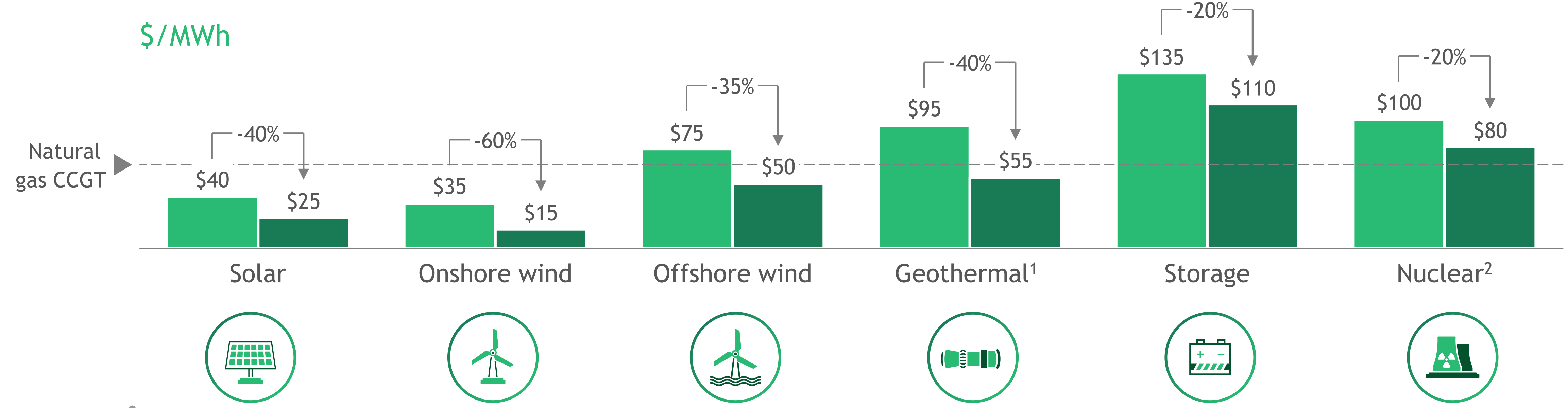


1. $1.6T is based off the optimistic forecasting scenario, does not include CHIPS Act funding. Note that the bar chart outlines both the base case and incremental annualized investment to total to the optimistic case. All numbers are rounded. 2. OECD
Source: EEI, EY, Credit Suisse, BCG Analysis

Funding reduces the cost of clean technologies, in many cases eliminating the green premium and making them cheaper than fossil fuel alternatives

Not Exhaustive

Levelized Cost of Energy (LCOE) pre- and post-tax credits



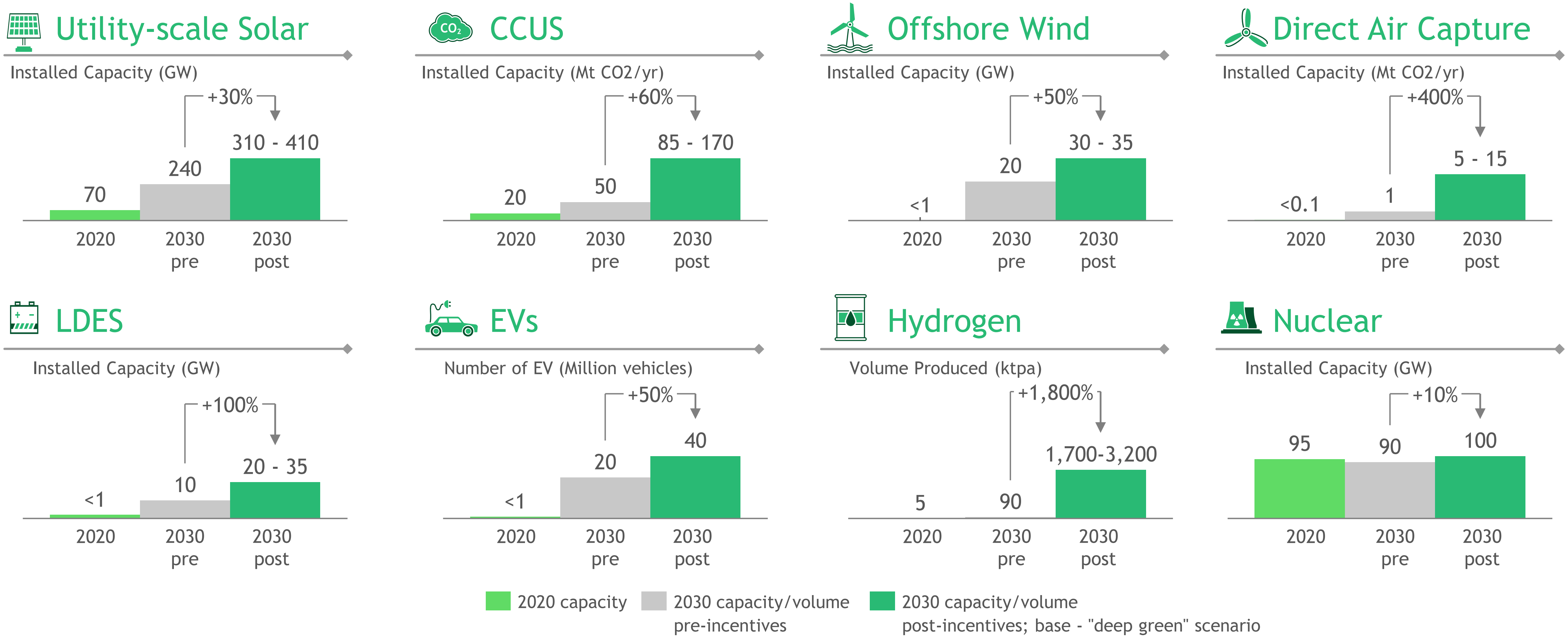
Post-IRA incentive applied	Solar	Onshore wind	Offshore wind	Geothermal[1]	Storage	Nuclear[2]
	50% Investment Tax Credit	$31/MWh[2] Production Tax credit	50% Investment Tax Credit	50% Investment Tax Credit	50% Investment Tax Credit	$31/MWh[2] Production Tax credit

Cost without tax credit | Cost with tax credit

1. Geothermal values reflect average of traditional flash and EGS technologies 2. New small modular reactor (SMR); 2.Assumes $15/MWh incentive, inflation adjusted and with bonuses;
Note: All technologies assume base + prevailing wage bonus + domestic production bonus + energy community bonus. All numbers rounded
Source: Lazard, IEA, BCG Analysis

Legislation cost reduction is expected to drive significant acceleration of clean technology deployment through 2030

Non-exhaustive



Source: BCG analysis

Additional non-cost barriers must be addressed across the value chain to capitalize on momentum and fully realize potential legislation upside

Obstacle	Obstructive Permitting	Limited enabling infrastructure	Supply chain constraints	Workforce development	High cost of early demo projects	Lack of rulemaking clarity
Description	Complex and lengthy permitting can slow down projects and add costs and uncertainty, especially for emerging technologies	Clean tech growth requires large-scale expansion of infrastructure, including the grid, pipelines, and storage	A significant scale up of domestic mfg. and resource extraction is needed to meet domestic content goals and prevent bottlenecks	~900K new jobs will be created from these clean technologies, requiring at-scale labor training and reskilling	Additional funding for early-stage research and demonstration is needed to bring down high costs and de-risk nascent technologies	Lack of federal rulemaking clarity can substantially impact complexity, costs, and timelines across technologies
Example	U.S. energy project permitting timelines	U.S. interconnection queues for renewable projects	Domestic mfg. capacity additions needed for solar	U.S. job growth under decarbonization scenarios	Cost comparisons of nascent techs from first-of-a-kind costs to N^{th}-of-a-kind	Impacts of unclear definitions and regulations on deployments

Example deep dives on following pages

Source: BCG analysis

Obstructive permitting | Permitting barriers can slow deployment by several years and remain a major blocker for scaling new technologies

US Permitting process faces significant challenges

4+ years

- Massive time investment (~4-16 years) to navigate long permit processes and increase community buy-in for clean energy, mining. Permitting time has doubled since 1970s

42% of projects are delayed

- Nearly half of clean energy ventures are delayed by regulatory red-tape, compared to just 15% in fossil fuel projects

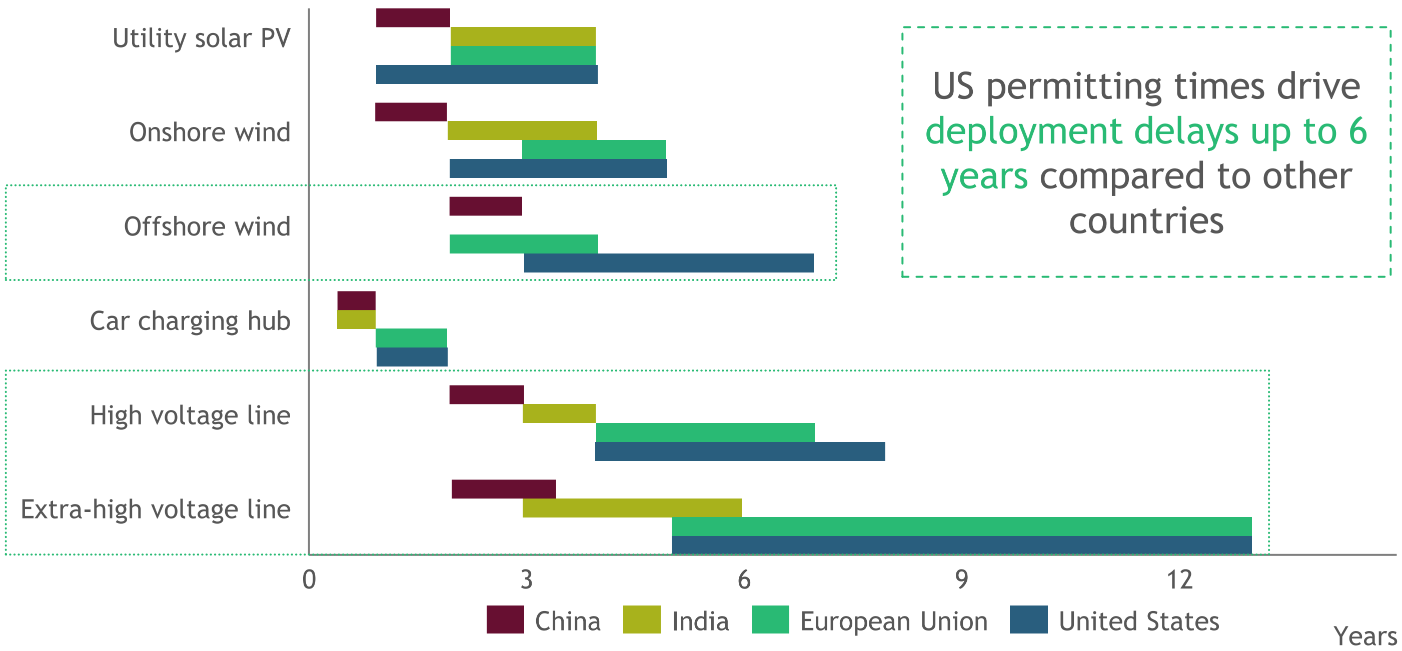
50 states

- Players must stay apace with state-specific and fast changing regulations to stay compliant in e.g., RES markets

IRA provides $350M in funding for Permitting Council to improve permitting efficiency and predictability

Example: U.S. permitting for energy projects lags other countries

Typical deployment time for electricity grids, solar PV, wind and EV charging stations



US permitting times drive deployment delays up to 6 years compared to other countries

Source: Congress Passes Inflation Reduction Act | Permitting Dashboard (performance.gov); For the Inflation Reduction Act to work, the US needs permitting reform | The Hill; Permitting Reform Needed to Reach Clean Energy Goals (c3newsmag.com), IEA WEO 2022, BCG analysis

Limited enabling infrastructure | Insufficient grid infrastructure drives growing interconnection queues and <5% completion for wind and solar projects

Insufficient infrastructure is a challenge across emerging technologies; for example:

Charging infrastructure must grow 14x from current levels to meet post-IRA 2030 EV demand

Transport & storage infrastructure must be built for both CO_2 and green hydrogen, separate from NG pipelines

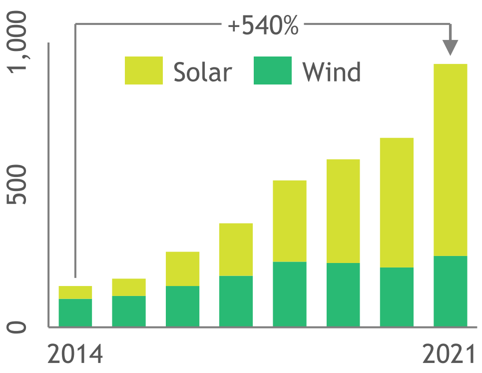
The U.S. must build 80+ vessels to meet offshore wind targets, including 5+ Jones Act compliant installation vessels

Deep dive

Transmission bottlenecks in the form of interconnection queues delay solar and wind projects

Steady growth in interconnection queues for solar and wind …

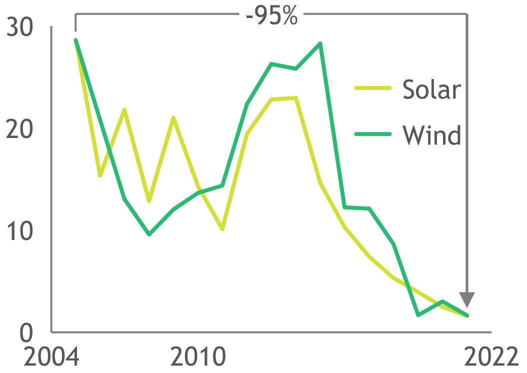
Total Capacity in Queues (GW)[1]



- Interconnection queues will continue to increase as requests grow due to IRA incentives
- Median duration from request to operation has increased from 1 year in 2008 to 4+ years in 2021

… lead to low and steadily decreasing completion rates …

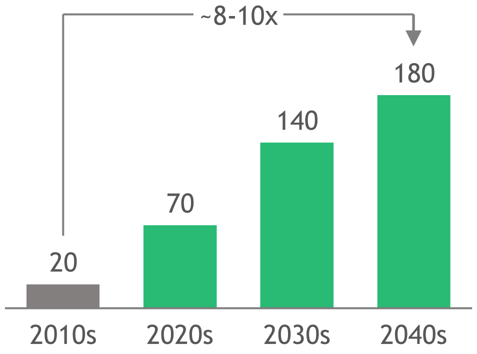
Project completion rate (%)[2]



- Steadily decreasing completion rates to below 5% inhibit renewable energy growth
- Without much needed grid expansion and modernization, bottlenecks are likely to grow

… requiring 8-10x increase in T&D investment to avoid bottlenecks

Annual U.S. investment in T&D ($B)[3]



- Existing grid is unable to support the influx of renewable energy
- Infrastructure needs to avoid bottlenecks and meet net zero by 2050 could require 8-10x higher annual T&D investment

1. From LBNL's 'Queued Up' report. 2. From LBNL's 'Queued Up' report; x-axis shows interconnection request year; completion percentage includes projects that have been withdrawn for reasons other than transmission bottlenecks. 3. From Princeton's 'Net-Zero America' report; calculates infrastructure investments needed under the net zero by 2050 scenario.
Source: Lawrence Berkeley National Laboratory (Queued up), IEA WEO 2022, Net-Zero America Report (Princeton), Domestic Offshore Wind Energy Supply Chain (NREL), BCG analysis

Supply chain constraints | Meeting domestic content goals requires significant scaling of domestic supply chains

Limited domestic capacity combined with local content requirements may create bottlenecks

Raw inputs for EVs and Li-ion grid scale storage

- IRA requires 40-80% of battery minerals to be sourced from the U.S. or country with free trade agreement
- Today, U.S. accounts for 1-2% of global raw materials extraction and processing, despite being the second largest country by EV sales

Offshore wind components manufacturing

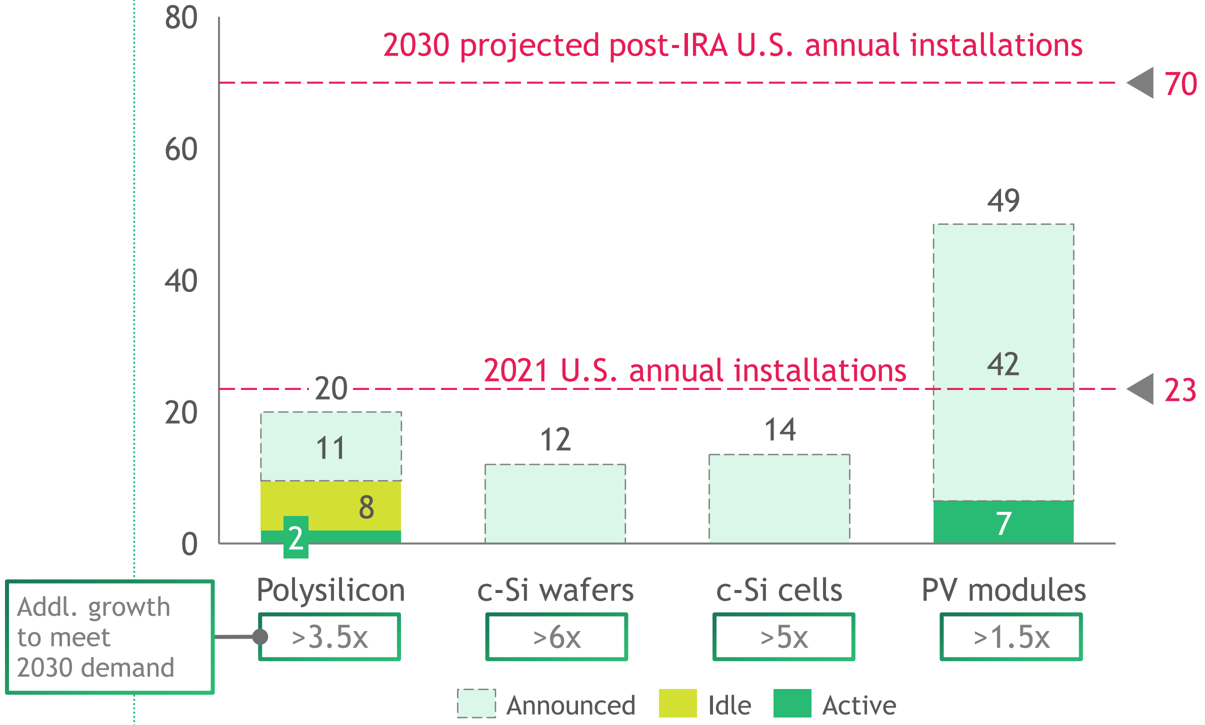
- Projects are eligible for IRA bonus credit if they meet 20-55% domestic content threshold for projects
- Majority of U.S. OEM facilities are still in early-stage development, with U.S. today having no offshore wind domestic manufacturing capacity

Solar manufacturing across the value chain

- IRA bonus credit is only available for projects that meet domestic content thresholds of 40-55%
- Across solar components, domestic mfg. capacity needs to increase 1.5-6x from announced capacity to meet 2030 domestic demand from domestic facilities

Solar mfg. deep dive | Domestic demand expected to exceed domestic supply, including announced facilities

Annual Manufacturing Capacity (GW)1

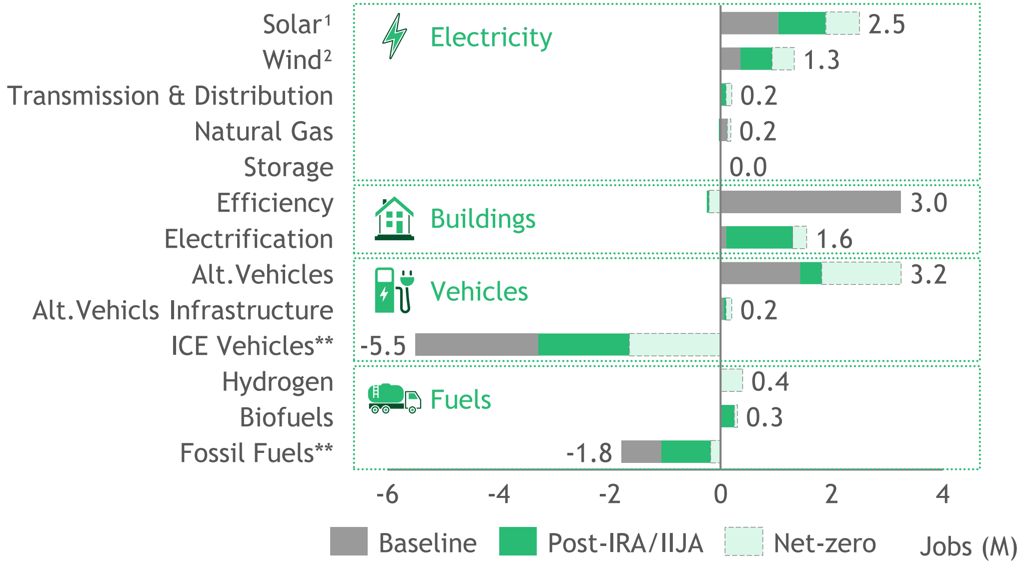


1. NREL Fall 2022 Solar Industry Update, solar installations are based on IEA's data from the World Energy Outlook 2022 under STEPS for post-IRA capacities.
Note: Domestic content bonuses are presented as a range since they increase over time. Source: IRA, DOE Solar PV Supply Chain Review, NREL Fall 2022 Solar Industry Update, BCG analysis

Workforce development | Incentives can drive creation of 5M+ new jobs, requiring adequate training and infrastructure to support the workforce

Energy transition is expected to drive net 4.3M new jobs post-IRA and IIJA expansion

Change in US employment by 2035

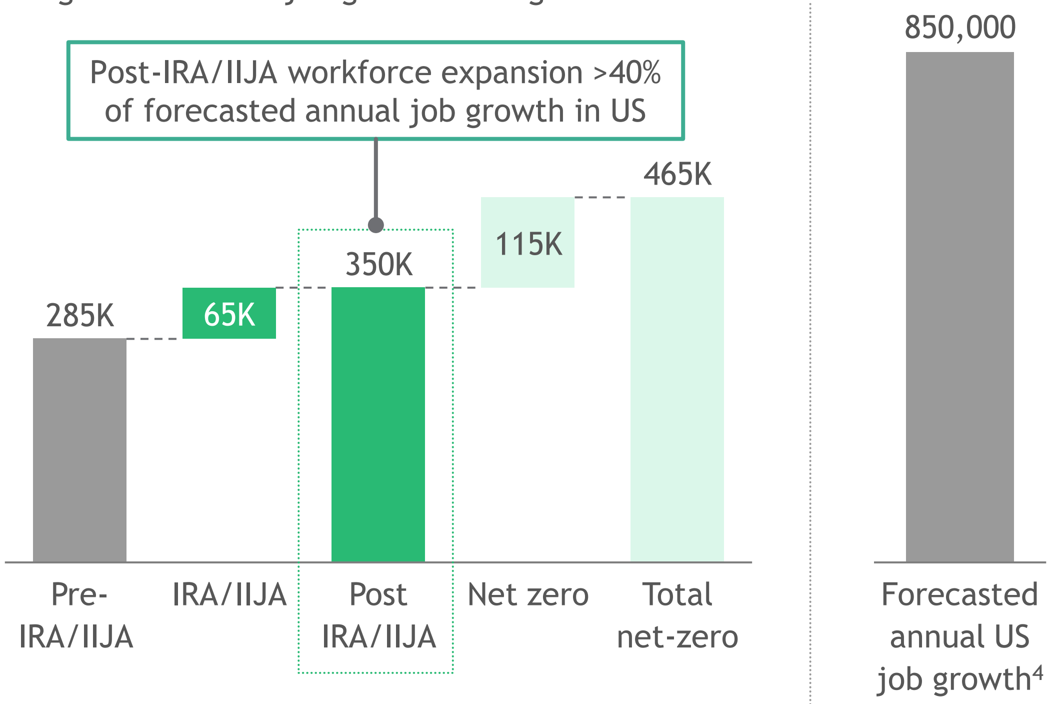


Legislation accelerates U.S. climate workforce adding nearly 1M net jobs beyond baseline expected growth of 3.4M

- Tax credits are tied to apprenticeship requirements
- $200M to Department of Energy establishes training to facilitate training

Unlocking IRA/IIJA benefits requires adding ~350K new trained workers to labor force each year

Avg. annual clean job growth through 2035[3]



1. Includes distributed and utility solar 2. Includes onshore and offshore wind; IRA drives growth in onshore 3. Average annual growth forecasted through 2031 (BLS) 3. Reflects total job growth through 2035 divided by 12 years. Note: All numbers rounded

Source: World Resource Institute; World Energy Employment job openings and labor turnover survey; Clean jobs America 2021, E2; BLS includes non-farm industries; BCG Analysis

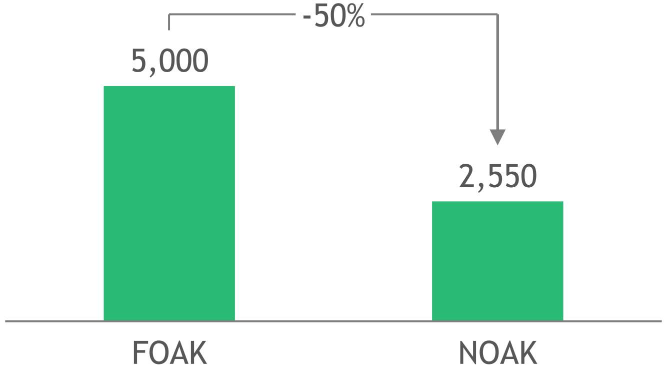
High cost of early demo projects | High costs for first of a kind plants are driven by increased technological and regulatory challenges

Early demonstration projects face increased challenges

1. **Technological uncertainty** increases cost of financing for early projects
   - Ex: Project risk and technology risk drove high financing costs for novel grid-scale battery projects, hurting early project economics and deployment
2. **Regulatory hurdles** slow down deployment, particularly for techs with high perceived risk
   - Ex: The licensing process for SMRs can take up to 5 years to complete, requiring patient long-term capital to sustain
3. **Lack of scale** makes it difficult to compete on cost and capture learnings
   - Ex: The LCOE of solar and wind has decreased by 90% and 70% since 2009 as demand increased and the technologies achieved economies of scale

Example 1: SMRs

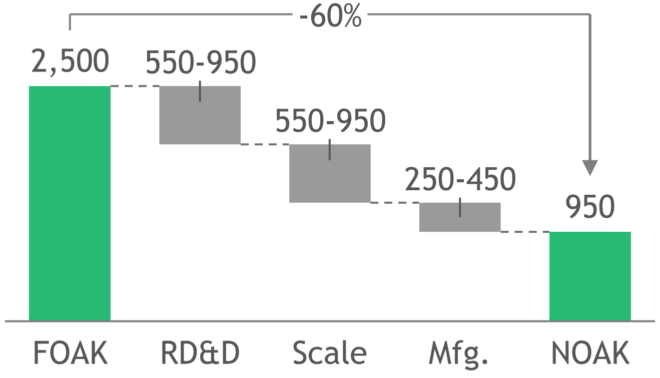
CAPEX [USD/kW][1]



FOAK costs that are ~2x higher than NOAK costs are driven by:
- High upfront capital costs without manufacturing scale
- Need for additional RD&D
- Expensive financing given tech risk and poor public perception

Example 2: LDES

CAPEX [USD/kW][2]



FOAK costs that are ~2.5x higher than NOAK costs can be driven down by:
- Increasing cost efficiency through RD&D improvements
- Capturing learnings from scale
- Improving manufacturing efficiency

Note: FOAK = First-of-a-kind, NOAK = Nth-of-a-kind
1. FOAK costs have been calculated by taking the average of FOAK costs from three key projects - Nuscale (US), Rolls Royce (UK), GEH (US). NOAK costs assume a 40% cost reduction in line with a 10% learning rate. 2. From LDES Council under the 24+ hour archetype and central (conservative learning rate) scenario
Source: Lazard LCOE 2022 Analysis, NRC, NREL Annual Technology Baseline, Net-Zero Power report (LDES Council), NRC, BCG analysis

Regulatory clarity | Lack of regulatory clarity causes uncertainty and delays deployment of public funding for key IRA and IIJA provisions

Undefined qualifying criteria for IRA and IIJA tax incentives

- Undefined rules for ITC and PTC "domestic content" and what will constitute the "end product"
- Lack of clarity on key ITC and PTC labor provisions
- Uncertainty whether contract manufactures will qualify for Advanced Manufacturing credit (45X) and how "produce" will be defined

Slows deployment of $175B in tax credits for wind and solar

Lack of clarity on CCUS and DAC IRS tax credit criteria and liability

- Undefined legal rules on geologic pore-space ownership & rights in property documents
- Outstanding clarity on IRS rules, including qualifying facility criteria, "stackability" of credits, etc.
- 100-year post-injection liability sharing negotiation between company and state

Slows ~$110B of DAC and CCUS 45Q and infrastructure funding

Questions on EV sourcing and supply chain incentives

- Unclear rules for determining sourcing requirements for battery components and manufacturing
- No clear process for validating extraction and processing requirements of "critical mineral streams"
- Lack of guidance on supply-chain tracking systems and how "value" will be assessed for battery components

Slows ~$20B of funding for EV consumer and manufacturing credits

Source: BCG analysis

Summary | Actions to further boost U.S. competitiveness

Key levers that will enable the U.S. to win the clean tech market

Reform obstructive permitting

Streamline and prioritize review/approvals process for zoning, safety, and environmental impact reviews

Invest in enabling infrastructure

Invest in electrical grid improvements and address interconnection backlogs for new deployments to support the rapid scale up of clean technologies

Relieve production input scarcity

Continue to build domestic mfg. capabilities and enhance funding for domestic supply of critical resources (e.g., lithium from geothermal brine)

Develop the workforce

Increase workforce development funding for skilled labor to meet increased labor force demand without shortages

Increase research funding

Increase funding for in-field research & commercialization of new technologies (e.g., SMRs, LDES) to de-risk for private investment

Provide regulatory clarity

Align on standards for incentives and implementation of IRA/IIJA (e.g., domestic sourcing requirements, carbon intensity, key definitions)

Source: BCG analysis

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