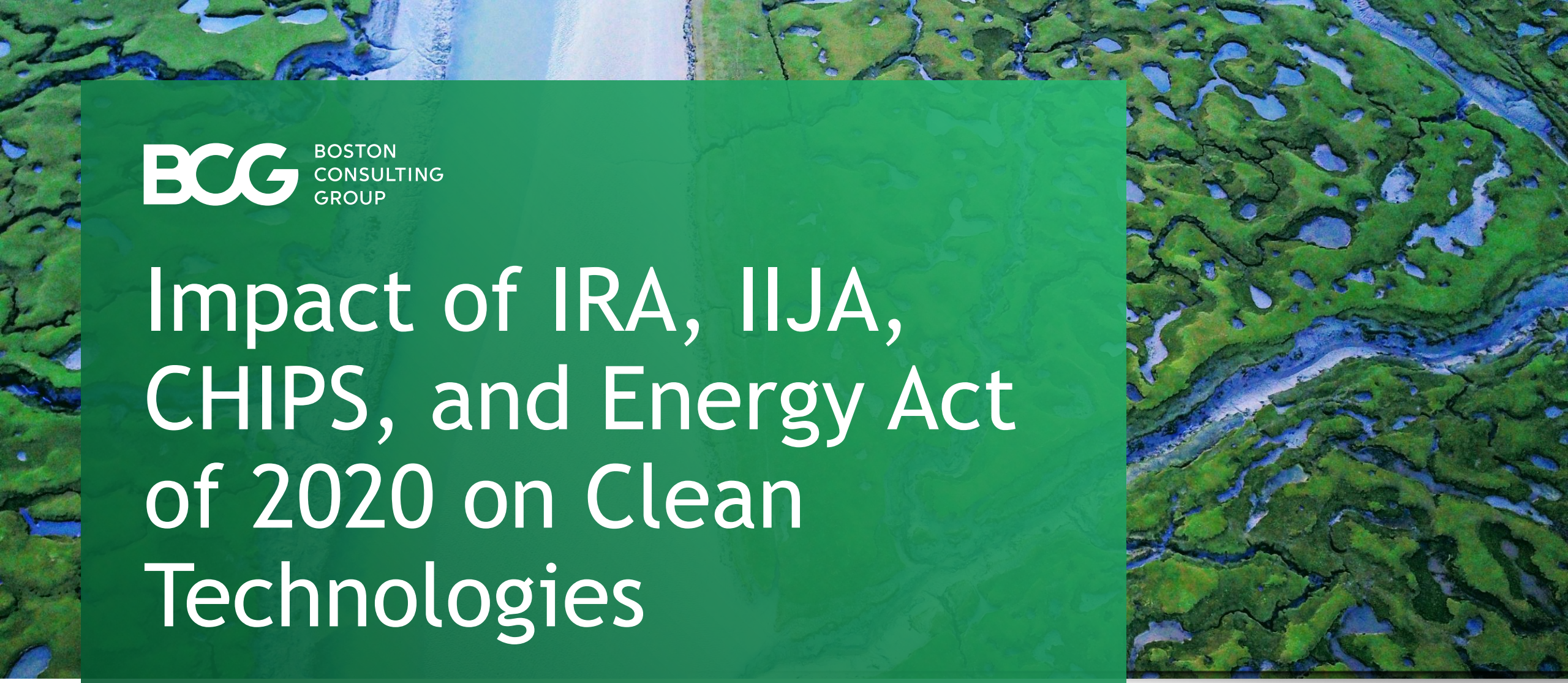


BOSTON CONSULTING GROUP

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

Deep Dive | Carbon Capture, Utilization, and Storage

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

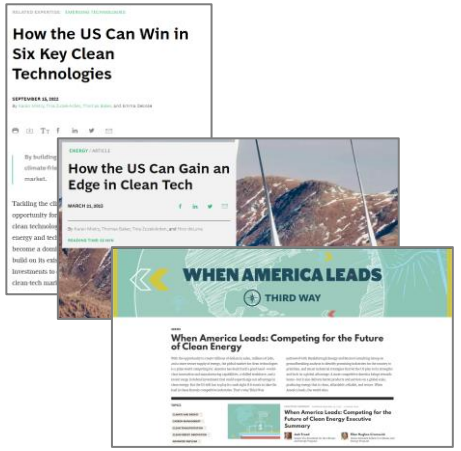
- Analysis was commissioned by Breakthrough Energy and Third Way, with input from stakeholders across the public and private sectors

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

Carbon Capture, Utilization, & Storage| Executive Summary

- Significant funding from the IRA and IIJA is expected to kickstart the US CCUS industry, driven by ~$3B in direct funding for early commercial projects[1] and an expanded $60-85/tCO2e 45Q tax credit, creating a first mover advantage for the US when competing in export markets
- Expanded tax credits will bring many CCUS applications into the money for the first time, with most industrial applications projected to cost less than the $85/tCO2e max credit value, improving project economics and incentivizing further investment and deployment
- Pairing these tax credits with ~$12B in funding for commercial projects & transport/storage infrastructure will make the US a global leader in CCUS with 85-170 Mtpa deployed by 2030, up from ~20 Mtpa today and 50-55 deployed by 2030 pre-legislation
- This market acceleration will allow the US to build domestic manufacturing hubs and expertise developing CCUS projects, increasing annual export potential and creating ~10k new jobs by 2030
- Exports and jobs will primarily be from equipment manufacturing, project development, and EPC[2] driven by US first mover advantage and relevant expertise in the domestic oil and gas industry
- To further support US competitiveness, future policies should focus on commercialization of R&D by US OEMs to drive down costs & capture global market share, along with streamlined permitting and long-term monetization schemes to allow project developers & EPCs to develop best practices and lead international projects early on (especially in the EU and Middle East)

1. Appropriations for an Energy Act of 2020 program 2. Engineering, procurement, and construction 3. 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: DOE; IEA; BCG Analysis

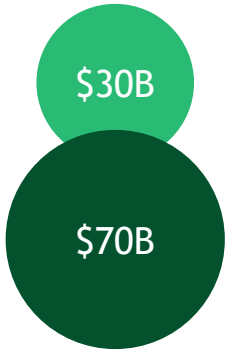
Recent US policies have resulted in significant increases in projected size of domestic market, exports, and jobs within CCUS

Impact of recent US policies (incl. IRA, IIJA) on cumulative market & job creation through 2030

US domestic market

US cumulative domestic market increased from ~$50B to ~$70B through 2030 after IRA/IIJA due to increased domestic deployments

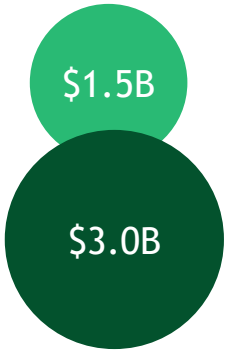
$B in market size



US exports

US cumulative exports through 2030 increased from $1.5B to $3.0B after IRA/IIJA due to expanded domestic manufacturing base and first mover advantage

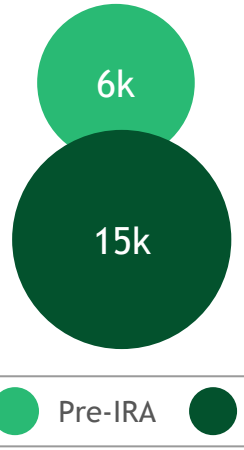
$B in exports



US job creation

New job creation in US CCUS industry through 2030 increased from ~6k to ~15k after IRA/IIJA due primarily to increased domestic deployments

Number of jobs

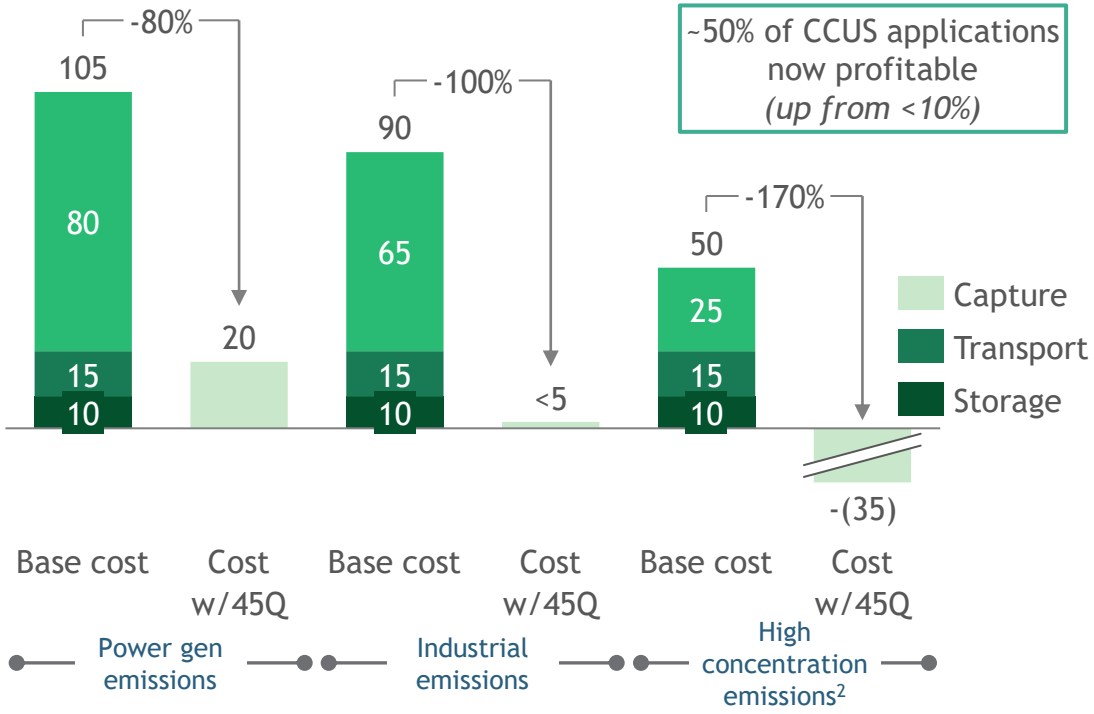


Note: All numbers based on IEA STEPS scenario based on change over timeframe from 2020-2030
Source: BCG analysis

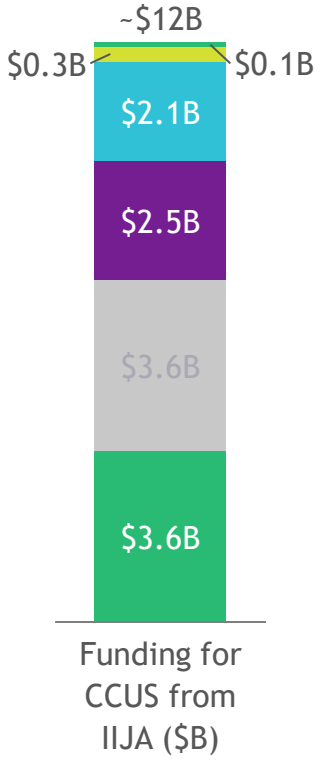
Expanded incentives| Expanded 45Q tax credits from the IRA and ~$12B in funding from the IIJA are the key drivers of this market expansion

45Q tax credits significantly decrease costs of CCUS across use cases with some becoming net profitable

Prior 45Q credit of $35-50/tCO2e increased to $60-85/tCO2e, making the addition of CCUS net profitable for certain use cases



~$12B in funding from IIJA supports early commercial deployments and lays groundwork for future growth



Secure Geologic Storage Permitting:
Grants for states to establish well permitting programs

Carbon Utilization & Procurement:
Grants for state/local gov't to procure products made from captured CO_2

Carbon Dioxide Transportation Infrastructure:
Low-interest loans for large CO2 pipeline projects

Carbon Storage, Validation, and Testing:
Funding for commercial large-scale carbon sequestration projects

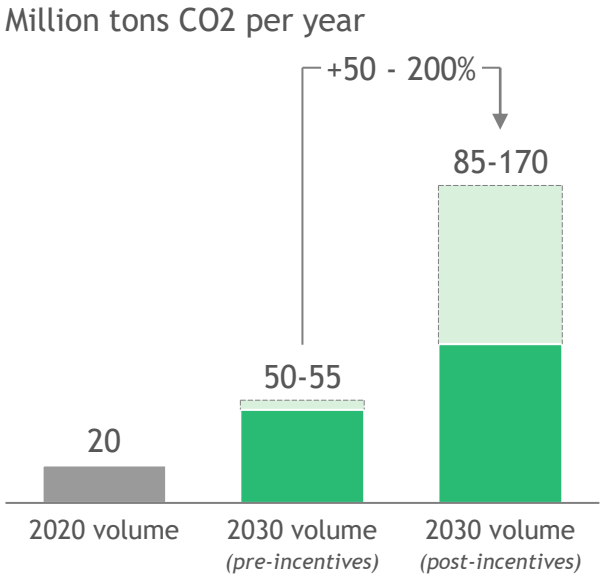
Carbon Removal (DAC):
Funding for 4 DAC hubs and pre-commercial demos (not CCUS but strong synergies). Includes $3.5B for DAC hubs and $115M in prizes for demos

Carbon Capture Technology Program:
Funding for R&D, pilots, and large-scale commercial projects (targeting 6)[1]. Includes $3.5B for pilots and demos & $100M for FEED program on CO_2 infra

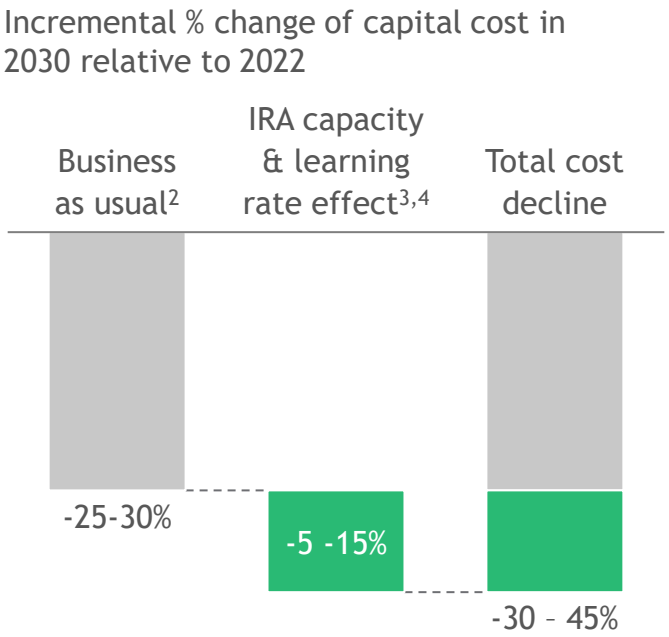
1. IIJA appropriated funds for an existing program created by Energy Act of 2020 2. Category includes several sources such as ammonia production and natural gas processing
Source: IIJA; IEA; BCG Analysis

Legislation impacts | US policies will catalyze investment in CCUS, growing projected capacity, driving down costs, and accelerating new jobs and exports

New policies accelerate CCUS capacity deployment…



… decreasing technology costs an incremental 5-15%%....



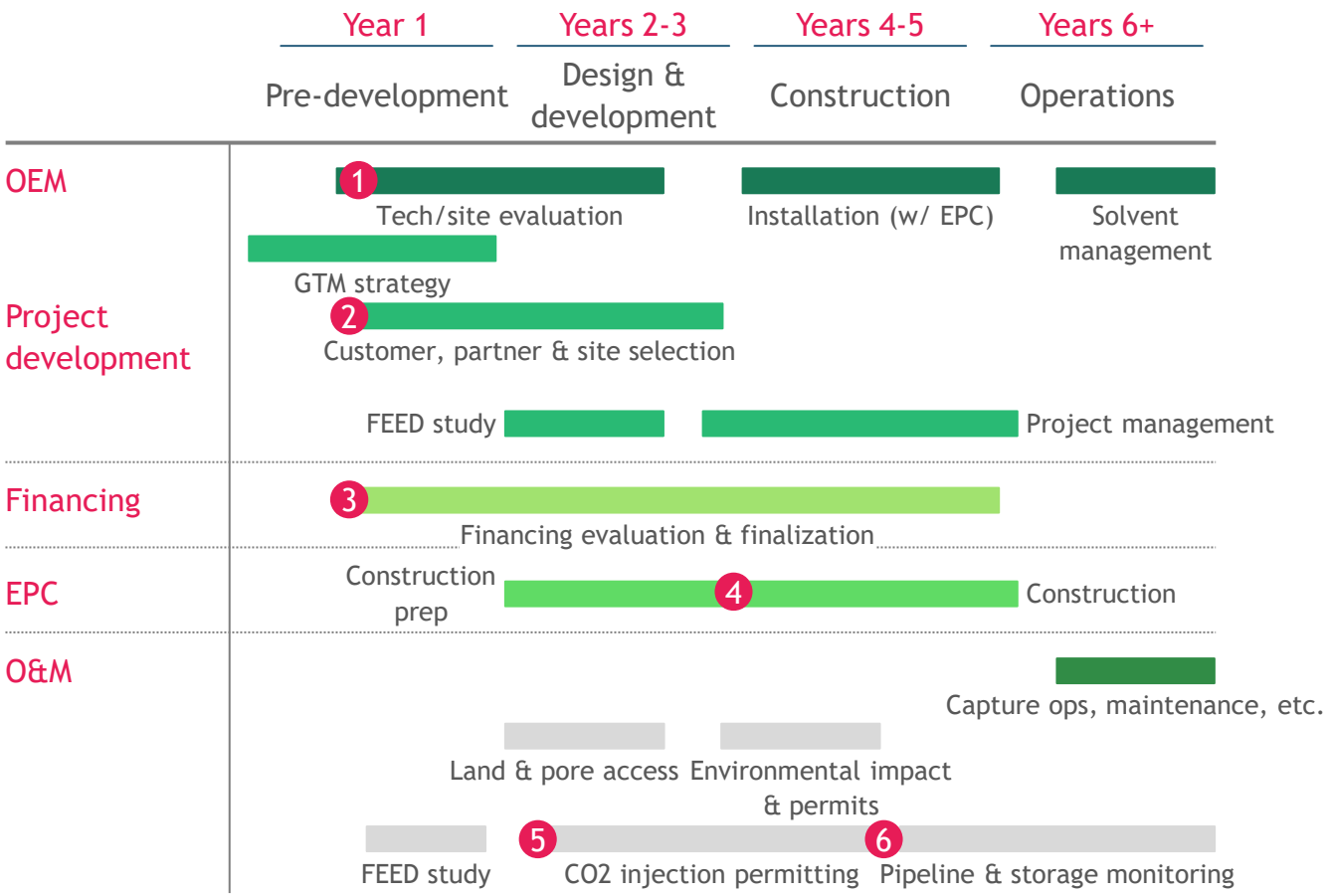
… and adding an additional ~10k jobs and ~$0.5B in exports

- $40B — **Incremental US market growth** catalyzed by IRA/IIJA incentives
- ~10K — **Incremental CCUS jobs** catalyzed by IRA/IIJA incentives
- $1.5B — **Incremental CCUS exports** catalyzed by IRA/IIJA incentives

1. 2030 cost projections do not account for inflation or subsidies 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)
Source: IEA; historical learning rate values from REFLEX; IIJA; BCG analysis

Pre-legislation challenges | CCUS deployment has been limited by both lack of monetization mechanisms and insufficient supporting infrastructure

Illustrative project timeline



Key pre-IRA gaps to be addressed

1. Many CCUS applications either too expensive or impractical for deployment
2. Limited regulations around CO2 emissions today limit widespread deployment of CCUS given lack of policy push
3. Long term monetization mechanisms needed to de-risk project financing
4. Long procurement timelines and difficulty obtaining/retaining talent slowing projects
5. Long permitting timelines and limited clarity on long-term storage and monitoring liability slows down project development
6. Insufficient infrastructure currently built out for source-to-sink matching

Source: ADB; International CCS Knowledge Center; BCG analysis

Remaining challenges | While recent legislation addressed some CCUS issues, additional non-cost barriers limit US competitiveness and deployment

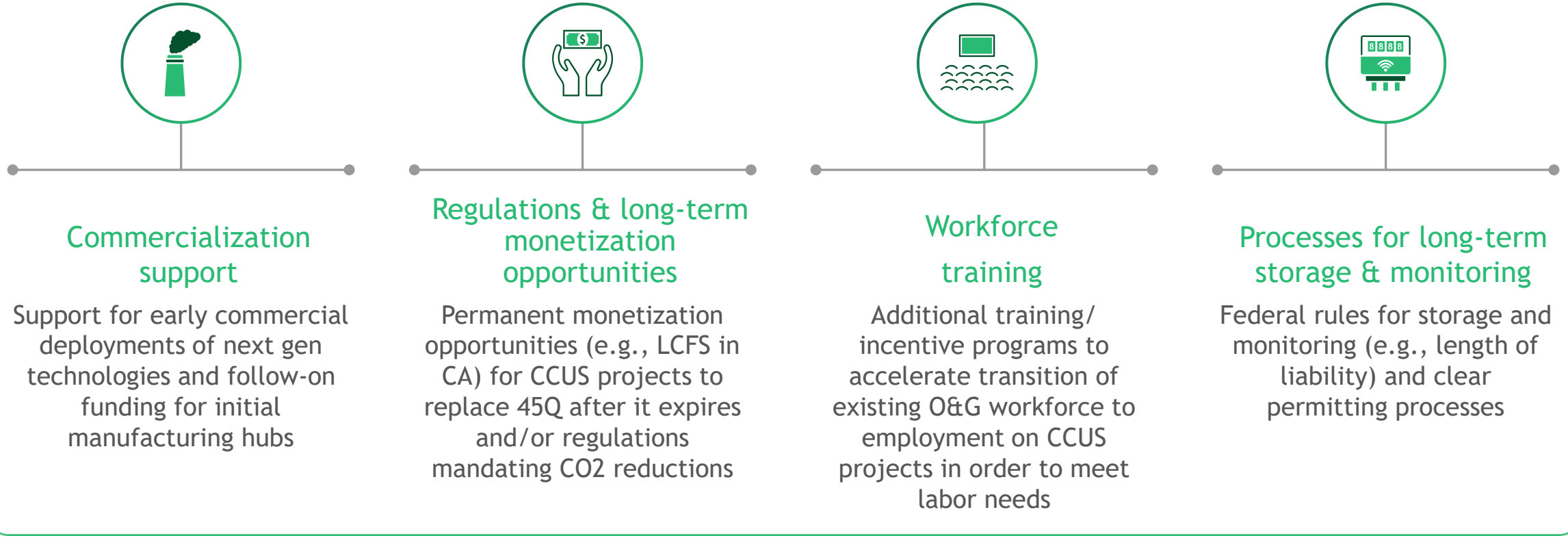
	Pre-legislation priority challenges	Changes from recent legislation (IRA, IIJA, CHIPS, and EA 2020)	Remaining areas to target with future policies
OEM	1 High cost/complexity of CCUS applications	• RD&D funding for novel & modular techs to drive down costs • IIJA funding for commercial-scale projects • 48C investment tax credit of up to 30%	☆ CCUS cost projections remains too high to support widespread deployment (esp. with bespoke model) and limited support for commercialization of US-developed tech
Project development	2 Limited regulations around CO2 emissions		☆ Limited demand for developing new CCUS projects and incurring related costs without CO2 emissions mandates or costs (by-sector or economy-wide)
Financing	3 Lack of long-term monetization mechanisms	• Expanded $60-85/tCO2e tax credit from 45Q in IRA	• Tough to incentivize investment given lack of long-term monetization opportunities to de-risk financing as 45Q credits expire after 12 tax years and construction needs to commence by 2033
EPC	4 Long procurement timelines and difficulty obtaining/retaining talent		☆ Insufficient workforce available to enable rapid deployment of CCUS without additional training programs & incentives for O&G workforce
Transport & Storage	5 Long permitting timelines and limited clarity on CO2 storage liability	• Direct funding for states to establish well permitting programs in IIJA	☆ Limited clarity on long-term storage & monitoring processes & liabilities at the federal level
	6 Insufficient CO2 transport & storage infrastructure	• Financing for both CO2 pipelines & large-scale carbon sequestration projects in IIJA	• Need further buildout of CO2 infrastructure to support CCUS hubs which will enable widespread deployment

☆ Priority areas

Source: C2ES; DOE; IIJA; IEA; BCG Analysis

Summary | Actions to further boost US competitiveness

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



Commercialization support

Support for early commercial deployments of next gen technologies and follow-on funding for initial manufacturing hubs

Regulations & long-term monetization opportunities

Permanent monetization opportunities (e.g., LCFS in CA) for CCUS projects to replace 45Q after it expires and/or regulations mandating CO2 reductions

Workforce training

Additional training/ incentive programs to accelerate transition of existing O&G workforce to employment on CCUS projects in order to meet labor needs

Processes for long-term storage & monitoring

Federal rules for storage and monitoring (e.g., length of liability) and clear permitting processes

Source: BCG Analysis

Backup | New legislation provides incentives for Carbon Capture, Utilization, and Storage (I/II)

	Provision	Summary	Type	Total investment
1	IRA Section 13104	Increases 45Q tax credit for sequestration and utilization to a maximum of $85/t for sequestration and $60/t for utilization with additional prevailing wage and apprenticeship requirements	Production Tax Credit (PTC)	$3.22B to 2033
2	IIJA Sec. 41004/Energy Act[1] Carbon Capture Demonstration & Pilot Program	Authorizes $3.5 billion for Carbon Capture large-scale pilot projects authorized by the Energy Act of 2020	Grant Funding	$3.5B to 2026
3	IIJA Sec. 40302/Energy Act[1] Carbon Utilization Program	State/local government grants to procure products derived from captured carbon. Expands DOE's Carbon Utilization program to include standards & certifications for commercialization of CO_2 products	Grant Funding	$310M to 2026
4	IIJA Sec. 40303/Energy Act[1] Carbon Capture Technology Program	Expands DOE's Carbon Capture Technology program to include front-end engineering & design for CO_2 transport infrastructure	Grant Funding	$100M
5	IIJA Sec. 40304 CO_2 Transportation Infrastructure Finance & Innovation	Establishes CO_2 Infrastructure Finance and Innovation Act, providing flexible, low-interest loans for CO_2 transport infrastructure projects & grants	Loan Authority/ Market Enabler	$2.1B • $600M for 2022-2023 • $300M for 2024-2026

1. Originally approved in Energy Act of 2020
Source: DOE; IRA; IIJA; BCG Analysis

Backup | New legislation provides incentives for Carbon Capture, Utilization, and Storage (II/II)

	Provision	Summary	Type	Total investment
6	IIJA Sec. 40305/Energy Act[1] Carbon Storage Validation & Testing	Expands DOE's Carbon Storage Validation & Testing program to include large-scale commercialization of new/expanded sequestration projects & transport infrastructure	Grant Funding	$2.5B to 2026
7	IIJA Sec. 40306 Secure Geologic Storage Permitting	Funding for permitting of wells for geologic sequestration of CO2 & creates grant program for states to establish Class VI permitting programs	Grant Funding	$75M
8	IIJA Sec. 40307 Geologic Carbon Sequestration	Allows DOI to permit carbon sequestration on outer Continental Shelf	Market Enabler	NA
9	CHIPS Sec. 10102	Establishes a "Carbon Sequestration Research and Geologic Computational Science Initiative" and at least two carbon storage research and geologic computational science centers	Market Enabler	$250M through 2027
10	IRA Section 13501: 48C Advanced Energy Manufacturing Project Tax Credit	Extension of the advanced energy manufacturing project credit. Base rate of 6% and 30% tax credit if wage and apprentice requirements are satisfied	Manufacturing Tax Credit	$10B

1. Originally approved in Energy Act of 2020
Source: DOE; IRA; IIJA; BCG Analysis

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