BCG

Private Capital and the Climate Opportunity in North America

NOVEMBER 2023

For institutional investors in North America, the challenges of climate change are creating correspondingly large opportunities for value creation.

New technologies are emerging that, if funded, could contribute significantly to achieving climate and sustainability goals. At the same time, government policies are unlocking significant capital and changing the return profile. For investors, the biggest hurdle is making sense of these opportunities.

Demand for climate investments is growing. Fundraising for climate funds nearly tripled in 2022, despite a 12% drop in private equity fundraising overall. That growth trend will accelerate. Between now and 2030, North America will require $6 trillion in additional capital if it is to stay on track to reach net zero by 2050. We estimate that private investors will commit up to eight times as much capital to the low-carbon economy by 2030 as they currently deploy. Government policies are a factor as well. The US has allocated $479 billion for climate and energy measures through the Inflation Reduction Act (IRA) and the Infrastructure Investment and Jobs Act. Similarly, Canada has allocated over $109 billion in federal incentives for climate transition technologies, in addition to adopting several province-level measures.

Despite their clear potential, these segments pose challenges to investors. Some companies are start-ups looking to fund first-of-a-kind commercial-scale facilities. Others are pursuing partnerships with corporates that need balance-sheet capital. Consequently, investors must weigh the risks related to new projects and technologies, higher capital intensity, and uncertain demand—often in the same opportunity. Traditional definitions of asset classes must expand in order for investors to pursue opportunities in this increasingly attractive space.

We analyzed eight climate subsectors that we believe can generate both climate impact and financial impact. (A similar BCG analysis looked at the climate opportunity for private capital firms in Europe.) Our findings are summarized in the following pages, which let investors review all eight subsectors in detail—including key opportunities along the entire value chain.

CCUS and DAC

Extensive use of CCUS and DAC to capture and offset emissions from hard-to-abate sectors is crucial to meeting decarbonization goals. The North America market is poised for rapid acceleration in these areas, as government incentives unlock project viability. In the US, the IRA increased the §45Q tax credit to $85 per ton for storage and $60 per ton for utilization, driving a step change in the volume of "in-the-money" emissions to more than 300 megatons—15 times the US's current capacity.

Capture	Transport	Storage	Adjacencies	
			Utilization	*Offsets*
Capture of CO_2 streams from stationary emitters or the atmosphere	Compression and transport via pipeline for storage or utilization	Permanent storage in the subsurface onshore or offshore	Repurposing of captured CO_2 for applications (e.g., sequestration, mineralization)	Generation and trading of carbon offsets from captured CO_2
Asset centric				
1 Integrated point-source capture, transport, and storage projects				
2 Facility-level point source capture	3 Midstream development and operation			
Technology centric				
4 Emerging capture technology			5 Emerging utilization technology	
6 DAC OEMs			7 Mature utilization applications	6 DAC OEMs
8 Compressors and other system components				
Service centric				
Technology provider handles EPC within facility	9 EPC and O&M services			

Source: BCG analysis.
Note: CCUS = carbon capture, utilization, and storage; DAC = direct-air capture; EPC = engineering, procurement, and construction; IRA = Inflation Reduction Act; O&M = operations and maintenance.
Non-exhaustive

CCUS and DAC: summary of opportunities (1/2)

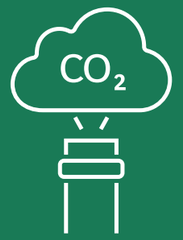
1	**Integrated point-source capture, transport, and storage projects**	· Development of a portfolio of integrated point-source capture-transport-storage projects · Stable cash flows offered by §45Q and offtake agreements, with potential internal rates of return of 10% to 25% depending on stream concentration and emitter density · Early-mover opportunity to capture high-concentration emitters, obtain right-of-way for transport infrastructure, and access scarce geological storage locations in high-density hubs
2	**Facility-level point source capture**	· Development of carbon capture infrastructure at emitters plugging into existing transport and storage infrastructure · Stable cash flows through revenue-sharing model with emitters for §45Q tax credits and CO_2 offtake · Early-mover opportunity to capture opportunities with high-concentration CO_2 streams in regions where transport and storage are not bottlenecked
3	**Midstream development and operation**	· Development of transportation and storage infrastructure to enable creation of CCUS hubs—either greenfield or converted legacy oil and gas infrastructure · Early-mover opportunity to secure right-of-way for transport infrastructure and scarce geological storage locations in high-density hubs to maximize returns
4	**Emerging capture technology**	· OEMs that develop carbon capture technology · Positioned for rapid growth as carbon capture deployment accelerates, unlocking economies of scale to improve the bottom line · Exposure to emerging technologies with cost reduction potential for low-concentration streams, unlocking further demand
5	**Emerging utilization technology**	· Developers of mineralization, chemical synthesis, and other emerging utilization technologies · Mineralization to make building materials: a mature technology with a large addressable market and multiple active early-stage players, with potential exit to cement companies · Chemical synthesis (e.g., to produce synthetic fuels): long-term tailwinds in hard-to-abate sectors, with economics expected to become more attractive as costs of renewable energy, low-carbon H_2, and catalysts decrease

Source: BCG analysis.
Note: CCUS = carbon capture, utilization, and storage; DAC = direct-air capture; EPC = engineering, procurement, and construction; IRA = Inflation Reduction Act; O&M = operations and maintenance.
Non-exhaustive

CCUS and DAC: summary of opportunities (2/2)

6	**DAC OEMs**	· OEMs that develop and deploy direct-air capture technology · Near-term, growing demand from corporations willing to pay a premium for permanent and verifiable engineered removals; long-term potential demand from synthetic aviation fuel · Path to 50%+ declines in cost by 2030, despite costs exceeding $500 per ton of CO_2 today · Significant valuation growth in funding rounds for market leaders; similar opportunities for emerging players as the market grows
7	**Mature utilization applications**	· Suppliers of CO_2 for various mature applications, such as food and beverage and industrial use · Opportunity to lock in low-cost CO_2 supplies from high-concentration streams (e.g., ethanol processing), creating a cost advantage as new end-use markets emerge · Limited alignment with climate mandates because applications typically do not result in permanent sequestration
8	**Compressors and other system components**	· Companies that produce and distribute compressors, tanks, valves, and other system components required for the CCUS value chain · Optimized go-to-market for players active in other subsectors to maximize the CCUS tailwind while retaining downside protection through end-market diversification
9	**EPC and O&M services**	· Engineering, procurement, and construction and operations and maintenance players active in CCUS development and operation, typically outside plant limits in transport and storage · Optimized go-to-market for players active in other subsectors, such as oil and gas, to maximize the CCUS tailwind while retaining downside protection through end-market diversification

Source: BCG analysis.
Note: CCUS = carbon capture, utilization, and storage; DAC = direct-air capture; EPC = engineering, procurement, and construction; IRA = Inflation Reduction Act; O&M = operations and maintenance
Non-exhaustive



Low-carbon hydrogen

Low-carbon hydrogen (H_2), a crucial decarbonization lever for many sectors, is expected to show sustained double-digit growth through 2050 in North America. In the near-term, IIJA funding of $8 billion for six to ten regional hubs and the IRA's production tax credit of up to $3/kg are likely to drive a sharp increase in projects. Although project economics should improve over time, early movers can gain an advantage by securing favorable production locations, rights-of-way for transport, and scarce geological storage.

H_2 production

Production of low-carbon H_2 and derivatives

H_2 logistics

Storage, transportation, and retail of low-carbon H_2 and derivatives

H_2 utilization

End-use of low-carbon H_2 in industrial, transport, power, and heat applications

Power	H_2 production	Storage	Transport	Retail	Industrial processes	Transport applications	Power & heat generation
Asset centric							
1 Renewable power generation	**2** Production facilities	**3** Transport and storage infrastructure		**4** Refueling stations	*Integrated into existing industrial facilities*	*H_2 fleet operator*[1]	*H_2 CHP plants*[1]
Technology centric							
	5 Electrolyzer OEMs					**6** Fuel cell OEMs	
	7 Mature system components (e.g., compressors, separation membranes)						
Service centric							
8 EPC and O&M services							

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction; IIJA = Infrastructure Investment and Jobs Act; IRA = Inflation Reduction Act; O&M = operations and maintenance.
[1]Limited in North America today.
Non-exhaustive

Low-carbon hydrogen: summary of opportunities (1/2)

1	**Renewable power generation**	· Onsite or offsite renewable generation to supply green H_2 production facilities that must maximize renewable electricity consumption in order to maximize the IRA production tax credit · Natural adjacency for developers of grid scale renewables, with the bonus, if onsite, of avoiding current grid interconnection bottlenecks
2	**Production facilities**	· Development of low-carbon H_2 or H_2-derivative (e.g., ammonia) production facilities—either greenfield or via retrofit of existing gray H_2 facilities · Rapid growth in domestic demand in North America for low-carbon H_2 through 2030, driven by industrial and transport applications · Enhanced US cost-competitiveness owing to the IRA production tax credit, creating export potential · Reduction in production costs of 30% or more by 2030, due to declining costs of electrolyzers and renewable energy
3	**Transport and storage infrastructure**	· Development of transport and storage infrastructure for low-carbon H_2, including compression, salt caverns, liquid tankers, pipelines, and CO_2 storage for blue H_2 projects · Early-mover opportunity to secure rights-of-way in high-density hubs and scarce geological storage locations; potential for cost reduction and patentable IP in storage · Investor access to opportunity through greenfield development or conversion of natural gas infrastructure
4	**Refueling stations**	· Development of H_2 refueling stations at transport nodes (e.g., ports and trucking stops) · Potential acceleration of emerging opportunity due to IRA incentives and improved fuel cell performance (e.g., California to build 200 stations by 2025) · Early-mover opportunity to secure the most attractive locations, capture long-term offtake contracts with fleets, and lock in low-carbon H_2 supply, driving predictable noncyclical cash flows

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction; IIJA = Infrastructure Investment and Jobs Act; IRA = Inflation Reduction Act; O&M = operations and maintenance.
Non-exhaustive

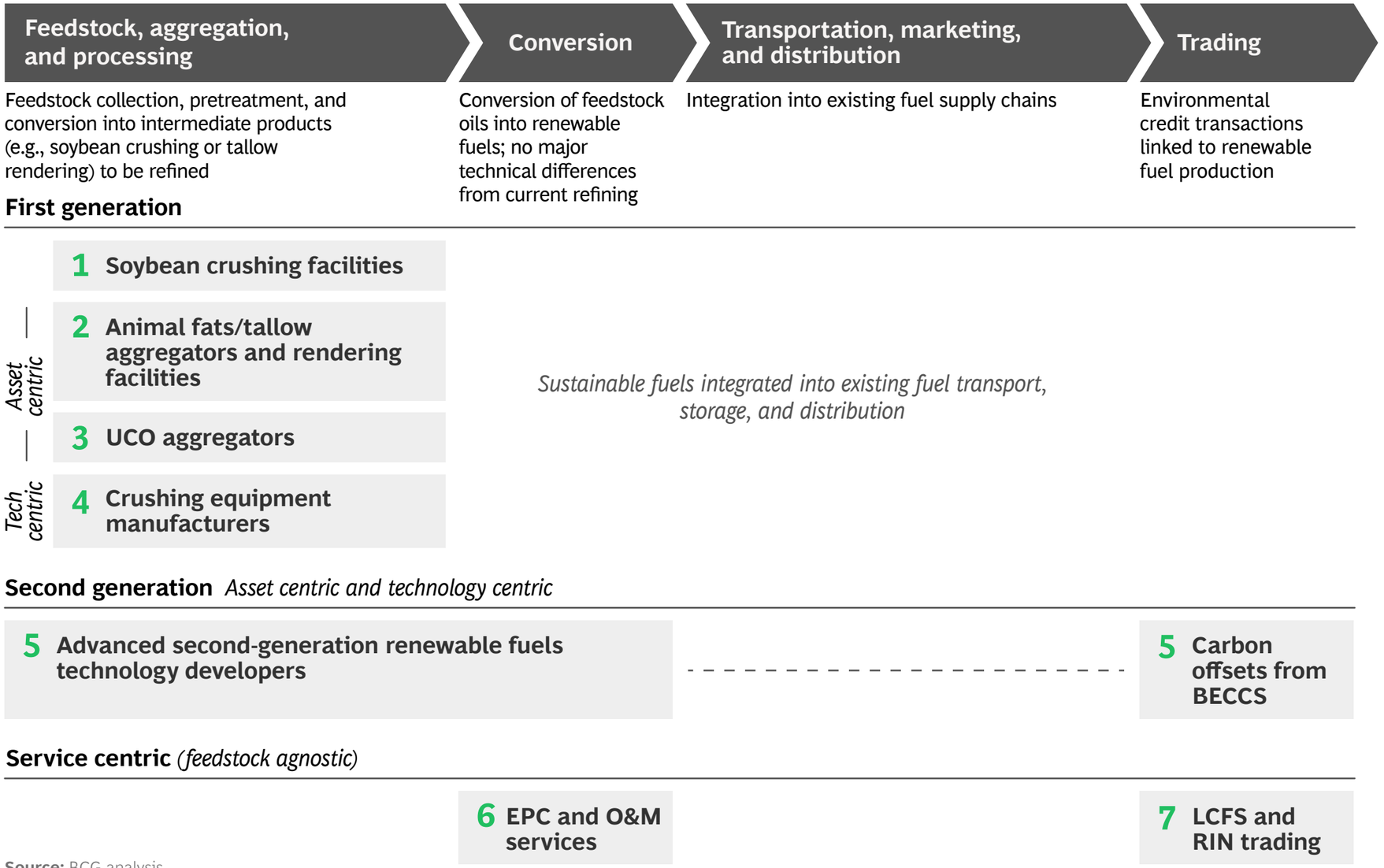
Low-carbon hydrogen: summary of opportunities (2/2)

5	**Electrolyzer OEMs**	· Companies that manufacture electrolyzers for green H_2 production · Projected 9X growth in electrolyzer production by 2025 to meet increasing demand · Path to profitability through scale · Investor opportunity to secure a stake in OEMs poised for technology and cost leadership as the market expands
6	**Fuel cell OEMs**	· Companies that manufacture fuel cells for mobile and stationary applications · Opportunity to shift from low or negative margins today to profitability, as a result of increased production scale · Opportunity to build durable advantage with patented technology and locked-in vehicle OEM relationships
7	**Mature system components (e.g., compressors, separation membranes)**	· Companies that produce and/or distribute compressors, separator membranes, storage tanks, valves, and other mature system components required along the H_2 value chain · Optimized go-to-market for players active in other subsectors to maximize the low-carbon H_2 tailwind, while retaining downside protection through end-market diversification
8	**EPC and O&M services**	· Engineering, procurement, and construction and operations and maintenance service providers that operate across the low-carbon H_2 value chain · Optimized go-to-market for players active in other subsectors to maximize the low-carbon H_2 tailwind, while retaining downside protection through end-market diversification

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction; IIJA = Infrastructure Investment and Jobs Act; IRA = Inflation Reduction Act; O&M = operations and maintenance.
Non-exhaustive

Sustainable fuels

Sustainable fuels are hydrocarbons made from organic waste (biofuels) or from H_2 and CO_2 (e-fuels) as replacements for fossil fuels. Biofuels are the more established category and offer the only at-scale solution for decarbonizing modes of transportation that cannot be electrified. These fuels have strong policy support, including a $6 billion allocation under the IRA, the adoption of LCFS in a growing number of US states and in Canada, and the likelihood that US federal RFS will drive strong subsector growth through 2030.



Source: BCG analysis.
Note: BECCS = bioenergy with carbon capture and storage; EPC = engineering, procurement, and construction; LCFS = low-carbon fuel standard; O&M = operations and maintenance; RFS = renewable fuel standards; RIN = renewable identification numbers; UCO = used cooking oil.
Non-exhaustive

Sustainable fuels: summary of opportunities (1/2)

Opportunity		
1	**Soybean crushing facilities**	· Development of facilities for crushing soybeans as a step prior to offtake to soybean oil refineries · Likely rapid increase in US soybean crushing capacity (currently at 90%+ utilization) to keep pace with growing renewable fuels demand · Announced expansions to increase capacity by 30% by 2025, with further increases needed by 2030 · Continued status of soybean oil as a key feedstock, due to its relative security of supply and consistency of quality, despite its sustainability properties being lower than other feedstocks
2	**Animal fats/tallow aggregators and rendering facilities**	· Companies that aggregate and render animal fat for refinery offtake · Position of animal fat an attractive middle ground for refiners between UCO and soybean oil—second to UCO in sustainability properties and LCFS revenue, and second to soybean oil in supply availability and quality consistency · Downside protection for aggregators/renderers due to opportunity to supply oleochemical and pet food industries in addition to renewable fuels
3	**UCO aggregators**	· Companies that collect, aggregate, and pretreat used cooking oil for offtake by refineries · Status of UCO as the feedstock of choice, with the highest LCFS revenue, due to having the lowest carbon intensity of first-generation and nonadvanced second-generation feedstocks · Opportunity for suppliers to capture incremental margin prices, forecasted to increase by 3X to 5X over 2020–2025 numbers · Opportunity for investors to create value by rolling up fragmented supplies to provide consistent quality and volumes to refiners
4	**Crushing equipment manufacturers**	· OEMs that produce soybean- and other oil-seed-crushing equipment · Benefit from tailwind of rapid increase in soybean-crushing capacity over the next decade · Downside protection for most players against sustainable fuel market risks as a result of diversification across end markets

Source: BCG analysis.
Note: BECCS = bioenergy with carbon capture and storage; EPC = engineering, procurement, and construction; LCFS = low-carbon fuel standard; O&M = operations and maintenance; RFS = renewable fuel standards; RIN = renewable identification numbers; UCO = used cooking oil.
Non-exhaustive

Sustainable fuels: summary of opportunities (2/2)

5	**Advanced second-generation renewable fuels technology developers and carbon offsets from BECCS**	· Companies that produce second-generation biofuels, often with proprietary processes and technologies · Vital role of second-generation fuels in meeting projected 2030 demand for sustainable fuels, with a potential price premium due to lower carbon intensity and land use impact · Early-mover opportunity to secure offtake agreements with key customers such as airlines and potentially scale rapidly through technology licensing
6	**EPC and O&M services**	· Engineering, and operations/maintenance service providers engaged in plant design, construction, and operations · Optimized go-to-market to maximize the sustainable fuels tailwind, while retaining downside protection through exposure to other subsectors such as oil and gas · Possible proprietary process and technology platforms owned by select engineering targets, creating durable advantage and recurring licensing revenue
7	**LCFS and RIN trading**	· Companies that aggregate and broker low-carbon fuel standard and renewable identification number credits from renewable fuel production · Arbitrage opportunity, given market fluctuations and geographical price differences · Downside protection for traders that operate across multiple environmental markets in addition to LCFS credits and RINs (e.g., renewable energy certificates)

Source: BCG analysis.
Note: BECCS = bioenergy with carbon capture and storage; EPC = engineering, procurement, and construction; LCFS = low-carbon fuel standard; O&M = operations and maintenance; RFS = renewable fuel standards; RIN = renewable identification numbers; UCO = used cooking oil.
Non-exhaustive

Renewable natural gas

RNG is produced through anaerobic digestion of organic feedstocks to produce biogas, which is then filtered to remove impurities and upgraded to methane. Upgrading allows direct injection of the final product into existing natural gas infrastructure. In North America, IRA investment tax credits of up to 50%, LCFS and RIN credit programs in the US and Canada, and cost recovery mechanisms for utilities are expected to drive strong growth through 2040. Even so, market expected to remain supply-constrained, creating pricing opportunities.

Haulers and aggregators	Conversion	Upgrading	Transportation, marketing, and distribution	Trading
Transportation and aggregation of feedstock	Conversion of feedstock to biogas through anerobic digestion	Filtering of impurities and CO_2 from biogas to allow direct injection into existing natural gas infrastructure	Integration into the existing natural gas supply chain	Environmental credit transactions linked to renewable natural gas production
Asset centric *Organic food waste, agricultural, landfill gas, wastewater*				
Hyperlocal market with limited roll-up synergies				
Production largely occurs onsite; no haulage needed	**2** Agricultural RNG facilities		*Integrated into existing natural gas transport, storage, and distribution*	
	3 Landfill gas RNG facilities			
	4 Wastewater RNG facilities			
Technology centric				
	5 Digesters, upgrading systems, and other production tech			
Service centric				
	6 EPC and O&M services			**7** LCFS and RIN trading

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction; IRA = Inflation Reduction Act; LCFS = low-carbon fuel standard; O&M = operations and maintenance; RIN = renewable identification numbers; RNG = renewable natural gas.
Non-exhaustive

Renewable natural gas: summary of opportunities (1/2)

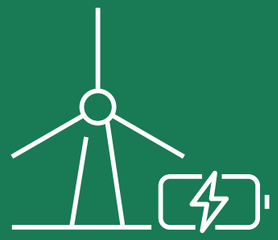
1	**Organic food waste RNG facilities**	· Development of facilities to convert organic food waste into RNG · Rapid growth expected despite lower ceiling on feedstock, buoyed by high LCFS revenue, corporate zero-landfill targets, and local landfill diversion regulations · Additional revenue through tipping fees, with some corporations willing to pay 20% premiums for landfill diversion · Optimal site selection with proximity to urban hubs for food waste and to alternative feedstocks critical for success
2	**Agricultural RNG facilities**	· Development of facilities to convert livestock waste into RNG · Rapid expansion of space over the past five years, outpacing the overall industry, supported by low carbon intensity, relative stability of supply, and California subsidies · Potential of agricultural waste to offer the largest economical supply of all major RNG feedstocks · Drawbacks of potentially low yield per site and potentially high cost of connecting additional farms to the cluster feeding the facility
3	**Landfill gas RNG facilities**	· Development of facilities to convert landfill gas into RNG · Status of landfill gas as the most mature RNG feedstock, accounting for the bulk of production today and posing a low risk of feedstock disruption · Drawbacks of ceilings on new landfill developments and limited opportunity to secure the most economically attractive landfills near gas networks
4	**Wastewater RNG facilities**	· Development of facilities to produce RNG from wastewater treatment plants · Reliable feedstock supply and lengthy contracts; also, in many cases, presence of onsite anaerobic digestors, which may lower capex · Drawbacks of low total availability vs. other feedstocks and potentially low site yield, requiring co-digestion with agricultural or food waste

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction; IRA = Inflation Reduction Act; LCFS = low-carbon fuel standard; O&M = operations and maintenance; RIN = renewable identification numbers; RNG = renewable natural gas.
Non-exhaustive

Renewable natural gas: summary of opportunities (2/2)

5	**Digesters, upgrading systems, and other production technology**	· Companies that design, manufacture, and service RNG production equipment · Various types of equipment (e.g., anaerobic digestors, upgrading systems, decanter centrifuges, and bioextruders) · Well-developed technology with innovation (e.g., in catalysts) offering incremental rather than disruptive improvement · Downside protection for most players through diversification across multiple oil and gas, petrochemical, and industrial applications
6	**EPC and O&M services**	· Companies contracted by developers to design, construct, and operate RNG production facilities · Highly fragmented market with limited technical differentiation, making developer relationships and project track record keys to success · Downside protection for most players due to diversification across oil and gas and chemicals end markets
7	**LCFS and RIN trading**	· Companies that aggregate and broker LCFS and RIN credits from renewable fuel production · Arbitrage opportunity, given market fluctuations and geographical price differences · Downside protection for traders that operate across multiple environmental markets in addition to LCFS credits and RINs (e.g., renewable energy certificates)

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction; IRA = Inflation Reduction Act; LCFS = low-carbon fuel standard; O&M = operations and maintenance; RIN = renewable identification numbers; RNG = renewable natural gas.
Non-exhaustive



Grid renewables and storage

Grid renewables and storage are set for rapid growth over the coming decade. In the US, IRA and IIJA tax credits, along with renewable power standards in 36 states, could shift generation to 65%–80% renewable by 2030 and increase nonresidential storage by 40x–50x. Significant investment in transmission infrastructure—as well as in generation and storage—will be needed to alleviate interconnection bottlenecks. The industry faces compressing returns, but these challenges also create opportunities to invest in technology and services that optimize performance.

Equipment	Development	Construction	Operations
Production of software and hardware for grid scale renewables	Land acquisition, engineering design, procurement, permitting, and financing for renewables projects	Logistics, installation, and commissioning for renewables projects	Asset management, operation, and maintenance to ensure project success

Asset centric

Generation — **1 Independent power producers**

Storage — **2 Utility-scale battery storage developers**

Transmission — **3 Transmission developers**

Integration across generation, storage, and transmission is common

Equipment/technology centric

4 LDES technology

Utility-scale battery integrators

Solar racking and tracking

5 Asset performance management technology

Service centric

6 EPC

7 Third-party O&M services

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction ; IIJA = Infrastructure Investment and Jobs Act; IRA = Inflation Reduction Act; LDES = long-duration energy storage; O&M = operations and maintenance; PPA = power purchase agreement.
Non-exhaustive

Grid renewables and storage: summary of opportunities (1/2)

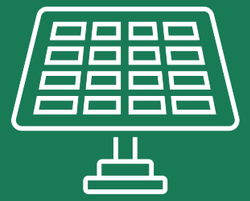
1	**Independent power producers**	· Development or acquisition of a portfolio of grid-scale solar or wind generation · Projected tripling of installed capacity by 2030 due to cost reduction and policy incentives · Need for developers and operators to navigate increased merchant risk and bottlenecks in grid connection and supply chain · Potential for developers to manage risk and maximize value through sophistication in project selection, scale for cost efficiencies, and financing structures to optimize cost of capital
2	**Utility-scale battery storage developers**	· Development or acquisition of a portfolio of utility-scale storage assets, either standalone or co-located with generation · Anticipated 40 times increase in installed utility storage from 2020 to 2030, driven by increased penetration of renewables and advances in battery technology · Significantly improved project economics as a result of addition of storage to the IRA's investment tax credit program
3	**Transmission developers**	· Development or acquisition of high-voltage transmission infrastructure · Need for significant investment to address grid interconnection bottlenecks and replace aging infrastructure · Expectation that IRA and IIJA funding will drive a $70 billion incremental investment in transmission through 2030 · Higher returns in transmission than in renewables for developers that navigate permitting hurdles and lengthy development timelines
4	**LDES technology**	· Companies that develop long-duration energy storage, with the capacity to store and discharge energy for eight or more hours · Greater renewables penetration possible with LDES owing to its cost-effectiveness than an overbuild of lithium-ion storage would accommodate · Anticipated 40 times growth in total addressable from 2025 to 2035 · Potential rapid growth in several emerging technologies approaching commercialization if they can demonstrate economics at scale

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction ; IIJA = Infrastructure Investment and Jobs Act; IRA = Inflation Reduction Act; LDES = long-duration energy storage; O&M = operations and maintenance; PPA = power purchase agreement.
Non-exhaustive

Grid renewables and storage: summary of opportunities (2/2)

5	**Asset performance management technology**	· Companies that provide software solutions to maximize the value of renewable generation and storage · Key functionalities of data aggregation, generation forecasting, price forecasting, predictive maintenance · Likely acceleration in penetration, with margin pressures increasing the need to optimize operations and with growing portfolio complexity · Varying player capabilities, which investors must navigate to pick winners
6	**EPC**	· Engineering, procurement, and construction contracted by developers for renewables, storage, and transmission design and construction · Likely to benefit from tailwind of grid investment over the next decade, with potential to roll up local and regional players
7	**Third-party O&M services**	· Renewables and storage third-party operations and management service providers · Source of best-practice maintenance to optimize performance, with faster response times than OEMs, along with multivendor flexibility · Most developed option in solar, with providers beginning to take share from OEMs in storage and wind

Source: BCG analysis.
Note: EPC = engineering, procurement, and construction ; IIJA = Infrastructure Investment and Jobs Act; IRA = Inflation Reduction Act; LDES = long-duration energy storage; O&M = operations and maintenance; PPA = power purchase agreement.
Non-exhaustive



Distributed energy and efficiency

Distributed energy resources encompass generation, storage, and efficiency technologies spanning residential and commercial/industrial segments. The space is growing rapidly in response to new technology, lower costs, favorable policies (including several relevant IRA incentives), and greater focus on sustainability and resilience. Historically siloed business models are converging through software and analytics, shifting competitive dynamics and creating new value pools.

	Equipment manufacturing	Wholesale and distribution	System/project design	Installation	Operations and maintenance	Analytics and aggregation
	Manufacturing of distributed energy and efficiency system components	Suppliers linking manufacturers with end-customers	Techno-economic design of distributed energy and efficiency systems	Installation of distributed energy and efficiency equipment	Management of installed system, with or without ownership in "as-a-service" model	Software solutions enabling maximization of value derived from installed systems
Solar	Solar racking	Electrical distributors and suppliers	Solar and storage system designers and installers		**1 C&I and community solar**	**2 VPP and DERMS**
	Microinverters and string inverters					
Battery storage	Battery OEM					
Smart metering and grid access	Smart meter OEM					
Electrified heating and cooling	HVAC, heat pump, sensor OEMs	HVAC, heat pump, sensor distributors and suppliers	**3 ESCO**			**4 BEMS**
Building automation and energy management						
EV charging	**5 EV-charging hardware OEMs**		**6 EV charge point operators**			**7 E-mobility service providers and charge point platforms**

8 Microgrids and energy-as-a-service

Source: BCG analysis.
Note: BEMS = building energy management system; C&I = commercial and industrial; DERMS = distributed energy resource management system; ESCO = energy service company; HVAC = heating, ventilation, and air conditioning; IRA = Inflation Reduction Act; VPP = virtual power plant.
Non-exhaustive

Distributed energy and efficiency: summary of opportunities (1/2)

1	**C&I and community solar**	· Development or acquisition of commercial and industrial or community solar photovoltaics and storage · Mature opportunity that continues to benefit from rising utility rates, falling solar/storage costs, and corporate decarbonization goals · Developers can create value through local market density, scale, and portfolio diversification, and disciplined project selection
2	**VPP and DERMS**	· Technology platforms that aggregate and optimize DERMS to dynamically interact with the grid · Potential for aggregated DERMS to receive compensation from the grid for deferred investment, demand response, and ancillary services, as well as to capture arbitrage opportunities in energy markets · Early stage of implementation despite FERC order 2222 mandating that regional transmission organizations and independent system operators accommodate DERMS aggregations
3	**ESCO**	· Companies that provide a range of efficiency services, including energy audit, solution design, financing solutions, and execution for commercial and public sector clients, under the umbrella term *energy service company* · Opportunities in an energy efficiency market that continues to be driven by aging infrastructure, corporate sustainability goals, rising energy costs, and government incentives · Consolidation opportunities possible among smaller players with deep local relationships but limited services and scale
4	**BEMS**	· Companies that supply software to dynamically monitor and control a building's energy needs with the goal of minimizing total energy cost · Fast-growing segment of the overall energy efficiency market that allows building owners to capture savings while deferring HVAC capex · In a market dominated by large OEMs, opportunities to invest in standalone players that can build niches with custom applications, establish white label partnerships with ESCOs, or serve underpenetrated segments

Source: BCG analysis.
Note: BEMS = building energy management system; C&I = commercial and industrial; DERMS = distributed energy resource management system; ESCO = energy service company; HVAC = heating, ventilation, and air conditioning; IRA = Inflation Reduction Act; VPP = virtual power plant.
Non-exhaustive

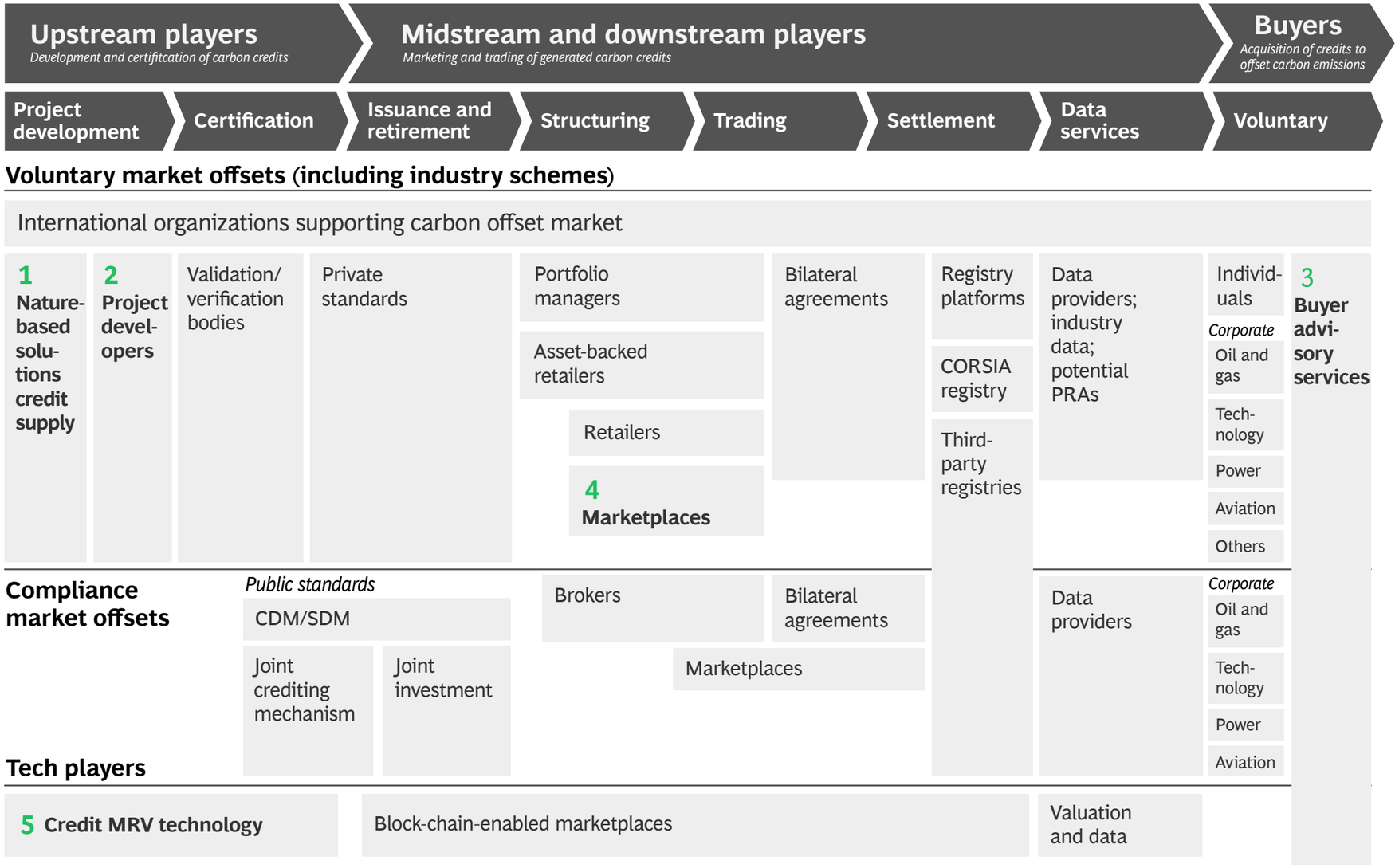
Distributed energy and efficiency: summary of opportunities (2/2)

5	**EV-charging hardware OEMs**	· Companies that manufacture charging equipment for electric vehicles, including private low-power AC wall boxes, public slow-charging terminals, and public DC fast-charging terminals · Opportunity to target production scale and partnerships with leading EV charge point operators, key success factors in this area
6	**EV charge point operators**	· Development and operation of public or fleet EV-charging infrastructure · With EV adoption growth, charging infrastructure will have to grow even faster given slower start · US public charging points expected to require $30 billion or higher capex through 2030, with IRA incentives offsetting cost in low-income and rural communities
7	**E-mobility service providers and charge point platforms**	· Software solutions for managing EV charge points, providing customer interfaces, and enabling interoperability across charging networks · Opportunity to pursue partnerships with leading EV charge point operators, a key success factor to realize scale
8	**Microgrids and energy-as-a-service**	· Companies that provide services, integration technology, and financing solutions for microgrids to enhance resilience, sustainability, and cost benefits · Potential to benefit from overlapping IRA incentives for renewable generation, efficiency, EV charging, and manufacturing

Source: BCG analysis.
Note: BEMS = building energy management system; C&I = commercial and industrial; DERMS = distributed energy resource management system; ESCO = energy service company; HVAC = heating, ventilation, and air conditioning; IRA = Inflation Reduction Act; VPP = virtual power plant.
Non-exhaustive

Nature-based solutions and carbon markets

The demand for voluntary carbon offsets is set to increase by 25 or more per year through 2030. Nature-based credits should continue to dominate the market because of their maturity and the increasing focus on co-benefits. Although supply will grow significantly, a supply gap is likely in the mid-2020s, leading to price opportunities. Multiple market frictions currently make the market inefficient, creating opportunities for technology solutions and services that address these challenges.



Source: BCG analysis.
Note: CDM = clean development mechanism; CORSIA = Carbon Offsetting and Reduction Scheme for International Aviation; MRV = monitoring, reporting, and verification; PRA = price reporting agency; SDM = sustainable development mechanism.
Non-exhaustive

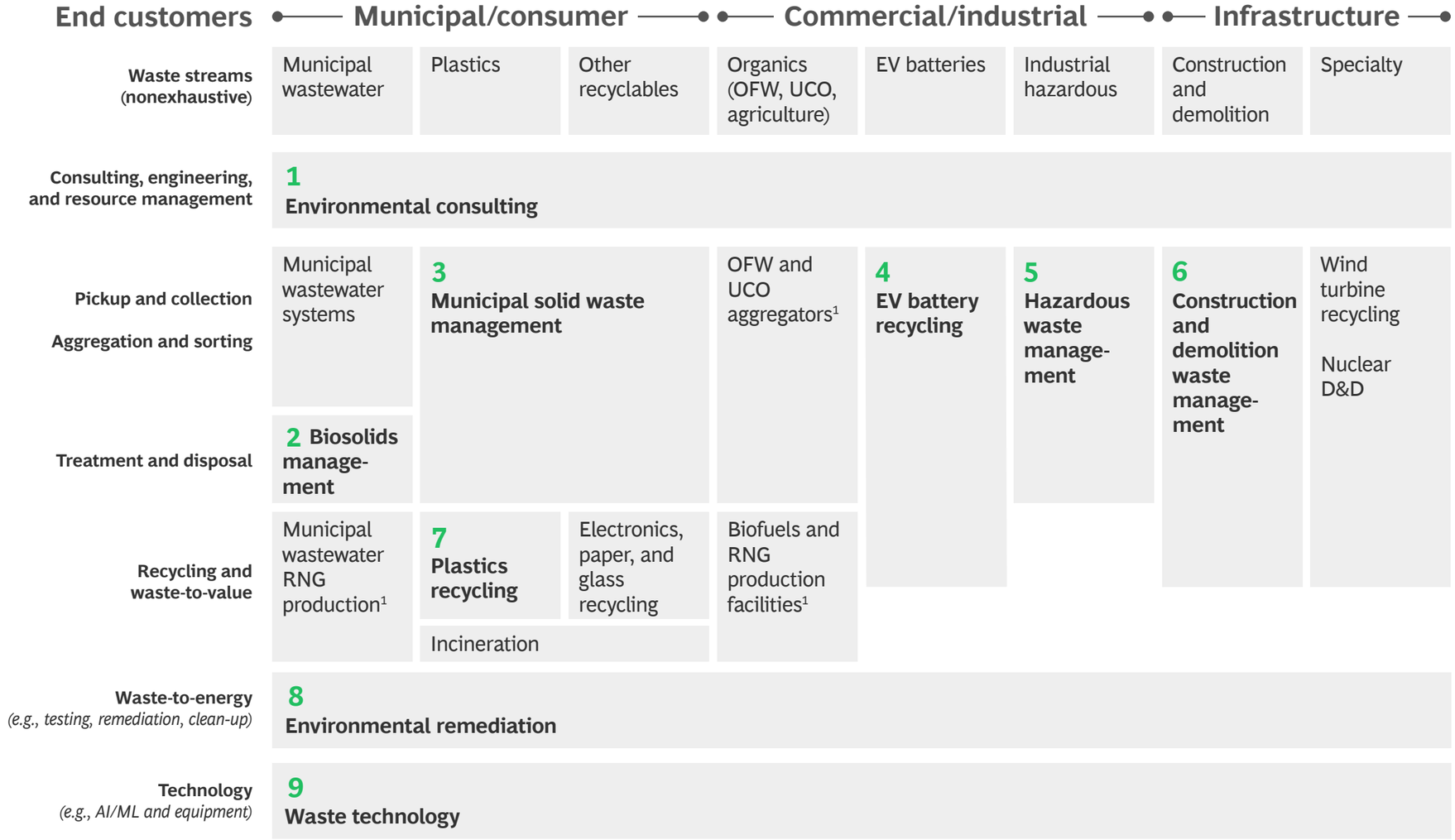
Nature-based solutions and carbon markets: summary of opportunities

1	**Nature-based solutions credit supply**	· Acquisition of land and development of nature-based offsets (e.g., through forest restoration and soil sequestration) · Flexibility to optimize for offsets or produced commodities such as timber, depending on prevailing prices · Opportunity for roll-up due to highly fragmented ownership of land in North America · Complexity in credit verification and price swings in both produced commodities and offsets markets
2	**Project developers**	· Companies that provide advisory services to developers to maximize offset generation and quality · Essential service for project developers seeking to navigate complex verification standards and buyer criteria · Opportunity to expand scope of offering through roll-up plays in a broad landscape of players with varying capabilities
3	**Buyer advisory services**	· Companies that advise credit buyers on purchase strategy for the voluntary and compliance markets · Essential service for buyers to ensure credible climate action as they navigate a fragmented offsets market with limited price visibility and widely varying offset quality · Opportunity to expand scope of offering through roll-up plays in a broad landscape of players with varying capabilities
4	**Marketplaces**	· Technology platforms that connect individuals and businesses to credit suppliers, offering greater transparency and lower transaction costs than over-the-counter brokers · A premium on players that have built partnerships with sizable credit suppliers and customers, as multiple early-stage platforms enter the market
5	**Credit MRV technology**	· Range of technology solutions for measurement, reporting, and verification of nature-based offsets · Key unlock to address market frictions related to verifiability, permanence, and additionality of offsets

Source: BCG analysis.
Note: CDM = clean development mechanism; CORSIA = Carbon Offsetting and Reduction Scheme for International Aviation; MRV = monitoring, reporting, and verification; PRA = price reporting agency; SDM = sustainable development mechanism.
Non-exhaustive

Waste management and recycling

The waste management and recycling subsector is transforming as a result of increased emphasis on protecting biodiversity and mitigating the environmentally harmful impact of extracting virgin materials. In North America, standards governing environmental discharges are tightening, and policies that extend producers' responsibility are under consideration. The subsector encompasses a wide array of businesses along the collection-sorting-treatment-recycling value chain. Investment theses across the landscape are underpinned by roll-up opportunities, long-term recession-proof contracts, and scarcity in the form of limitations on permits or access to high-demand recycled materials.



Source: BCG analysis.
Note: AI/ML = artificial intelligence/machine learning; D&D = deactivation and decommissioning; EV = electric vehicle; IIJA = Infrastructure Investment and Jobs Act; OFW = organic food waste; RNG = renewable natural gas; UCO = used cooking oil.
[1]See "Sustainable fuels" and "Renewable natural gas" tabs.
Non-exhaustive

Waste management and recycling: summary of opportunities (1/2)

1	**Environmental consulting**	· Environmental consulting services that support companies in designing effective waste management programs to mitigate risks associated with regulatory compliance and reputation · Tailwinds from tightening regulation, enhanced reporting requirements, and ESG pressure · Consolidation opportunities involving niche players that specialize in specific segments that might be used to build more comprehensive offerings
2	**Biosolids management**	· Development and operation of facilities for physical and chemical treatment of sewage sludge to produce biosolids for fertilizer use · Recession-resistant long-term contracts with wastewater facilities, with demand for biosolids benefiting from circularity and sustainability tailwinds in agriculture · Fragmented landscape, with 200+ regional players in US, presenting roll-up opportunities to drive operational efficiency
3	**Municipal solid waste management**	· Services and facilities for collecting and sorting municipal solid waste for ultimate transfer to recyclers or landfill · Stable market on a trajectory to grow with GDP, bolstered by sticky, recession-resistant municipal contracts · Fragmented tail of local companies that could be targets for roll-up plays to improve operational efficiency
4	**EV battery recycling**	· Companies that recover critical minerals from end-of-life EV batteries, often using proprietary technology · Critical area to meet growing EV battery demand, given the fundamental shortage and geopolitical risk associated with several key minerals · Lock-up tail of scarce supplies and establishment of offtake agreements with manufacturers essential for plant scale and profitability
5	**Hazardous waste management**	· Services and facilities for collection, treatment, and disposal of hazardous industrial waste · Opportunity to generate roll-up synergies through improved geographical density and operational efficiencies, in light of long tail of regional players · Potential to leverage an asset to build a platform through numerous adjacent services (e.g., industrial cleaning and emergency response)

Source: BCG analysis.
Note: AI/ML = artificial intelligence/machine learning; D&D = deactivation and decommissioning; EV = electric vehicle; IIJA = Infrastructure Investment and Jobs Act; OFW = organic food waste; RNG = renewable natural gas; UCO = used cooking oil.
Non-exhaustive

Waste management and recycling: summary of opportunities (2/2)

6	**Construction and demolition waste management**	· Services that divert construction debris from landfill through recycling/reuse to reduce the impact of extracting virgin resources · Expected tailwind for the market due to IIJA's boost to construction · Opportunity to target fragmented tail of local companies for roll-up plays to improve operational efficiency
7	**Plastics recycling**	· Facilities for recycling plastics by various means, the most promising of which is use of pyrolysis to produce feedstock for petrochemical plants · Tailwinds from voluntary corporate action to reduce plastic waste and from tighter regulations such as rules that extend producer responsibility · Key roles of feedstock stability and offtake stability for pyrolysis plants
8	**Environmental remediation**	· Providers of technology and services for removing pollutants or contaminants from water and soil · Tailwinds from rising environmental protection standards and an installed base of older infrastructure that requires abatement (e.g., lead and asbestos) · Opportunity to pursue roll-up plays in fragmented tail of local companies to improve operational efficiency
9	**Waste technology**	· Companies that develop sensors, software, and robotics solutions to optimize processes throughout the waste management and recycling value chain · Tailwinds from broader circularity drivers, tightening labor costs for material recovery facilities, and growing capabilities of AI/ML · Numerous early-stage companies along the value chain with potential to secure recession-resistant municipal contracts

Source: BCG analysis.
Note: AI/ML = artificial intelligence/machine learning; D&D = deactivation and decommissioning; EV = electric vehicle; IIJA = Infrastructure Investment and Jobs Act; OFW = organic food waste; RNG = renewable natural gas; UCO = used cooking oil.
Non-exhaustive

Private Capital and the Climate Opportunity in North America

EXPLORE THE INTERACTIVE ON BCG.COM