BOSTON CONSULTING GROUP

BRAZIL CLIMATE REPORT 2022

Seizing Brazil's Climate Potential

Brazil Climate Summit.

BRAZIL CLIMATE SUMMIT
September 15-16th, 2022

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About this report

Objective	This report is a call-to-action for Brazilian leaders, decision-makers and citizens to catalyze efforts, tackle challenges & maximize value from opportunities intrinsic to BR during the transition of World's economy to Net-Zero (2020-50). It is forward-looking and solution-oriented, while acknowledging, prioritizing and tackling BR challenges.
Audience	This report was built for all those willing to drive actions against Climate Change in Brazil (e.g., investors, board members, executives, entrepreneurs, academia, etc.), from anywhere in the world, especially those who believe in Brazil's Green potential
Data	This document is a compilation of public information and BCG expertise, carefully selected, to bring numbers and facts to Climate discussions and decision-making. It must be revisited and updated annually, to reflect our rapidly changing society
Special thanks	BCG is thankful to the support received by the entire organizing team of Brazil Climate Summit, especially to all Brazilian students at Columbia University who first decided to turn this dream-event into reality, contributing to accelerating the path to Net-Zero (www.brazilclimatesummit.com)

How to navigate this report?

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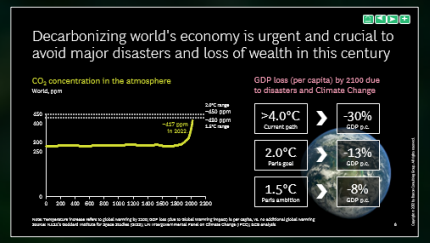
Executive summary

Brazil is uniquely positioned and has a clear path ahead to trigger effective climate solutions at scale for the world

1

Transition to Net-Zero will require the world to invest $100-150T across 3 decades

- Crucial to avoid disasters & up to ~30% in GDP loss
- Peak by ~2030 ($10T/year)
- The world will need core climate solutions at scale



2

Brazil is already ahead in offering concrete climate solutions at scale today

- BR power matrix is already ~85% clean (vs. 26% world)
- 20+ Mn Ha of RegAg[1] today
- BR Industry and Transport benefit from lower GHGs[2]

3

BR is well-positioned to be a Net-Zero catalyst and attract $2-3T of investments by 2050

- Potential to lead in RegAg[1], NBS[3], Green H_2 & Industry
- Potential to almost double private investment by 2030
- AFOLU[4] as critical enabler

4

Leaders are urged to engage & boost BR climate potential

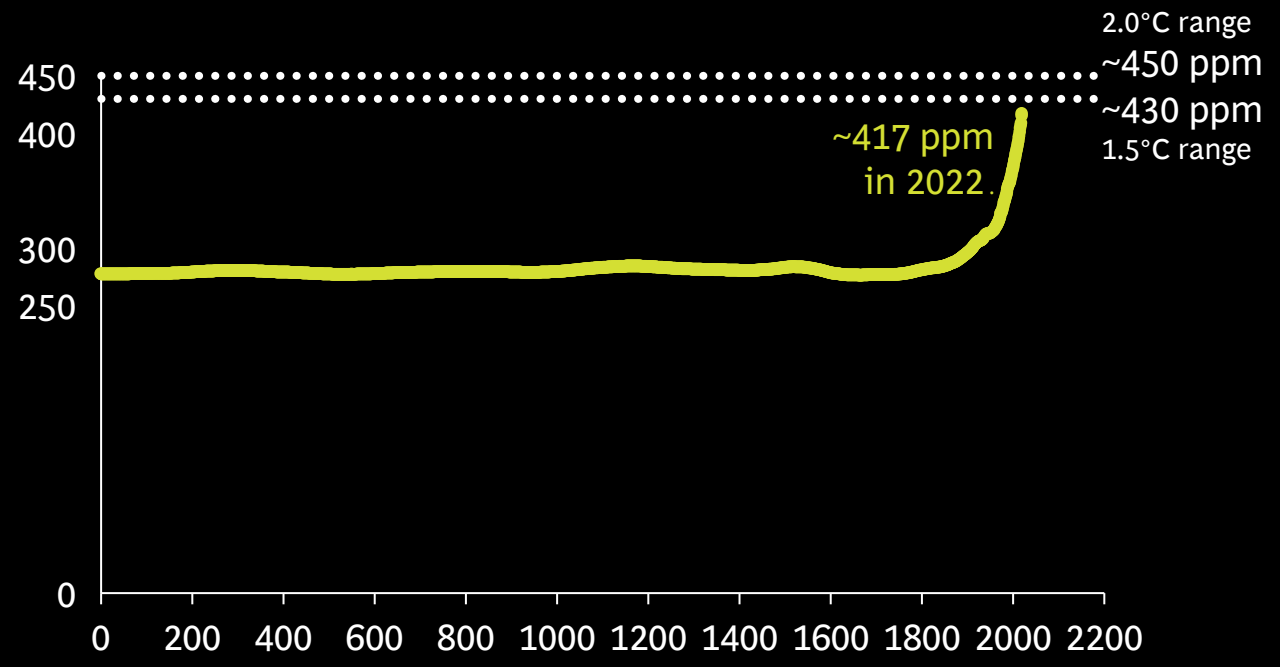
- BR as a global protagonist in the Net-Zero pathway...
- ... creating value from its forests and agriculture...
- ... & supplying low-carbon industrial goods, globally

1. Regenerative Agriculture (KPI for Crop-Livestock-Forest Integration) 2. Greenhouse gases 3. Nature-Based Solutions 4. Agriculture, forestry & other land use; Source: BCG's Brazil Climate Report 2022; BCG analysis

Decarbonizing world's economy is urgent and crucial to avoid major disasters and loss of wealth in this century

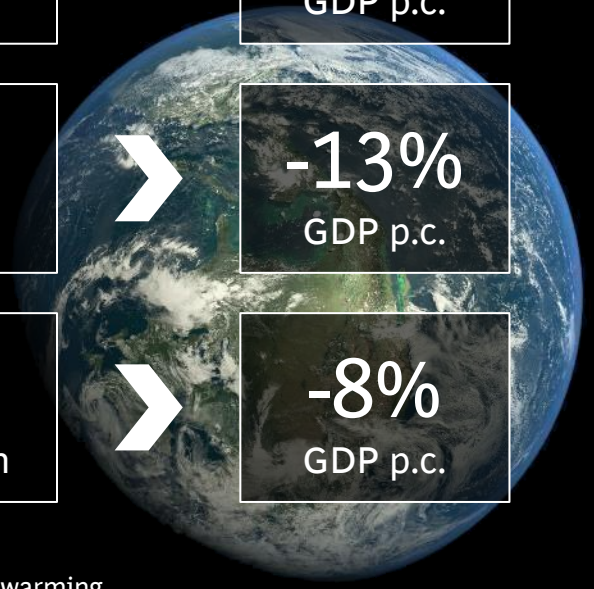
CO_2 concentration in the atmosphere

World, ppm



GDP loss (per capita) by 2100 due to disasters and Climate Change

>4.0°C Current path	-30% GDP p.c.
2.0°C Paris goal	-13% GDP p.c.
1.5°C Paris ambition	-8% GDP p.c.



Note: Temperature increase refers to global warming by 2100; GDP loss (due to Global Warming impact) is per capita, vs. no additional global warming
Source: NASA's Goddard Institute for Space Studies (GISS); UN Intergovernmental Panel on Climate Change (IPCC); BCG analysis

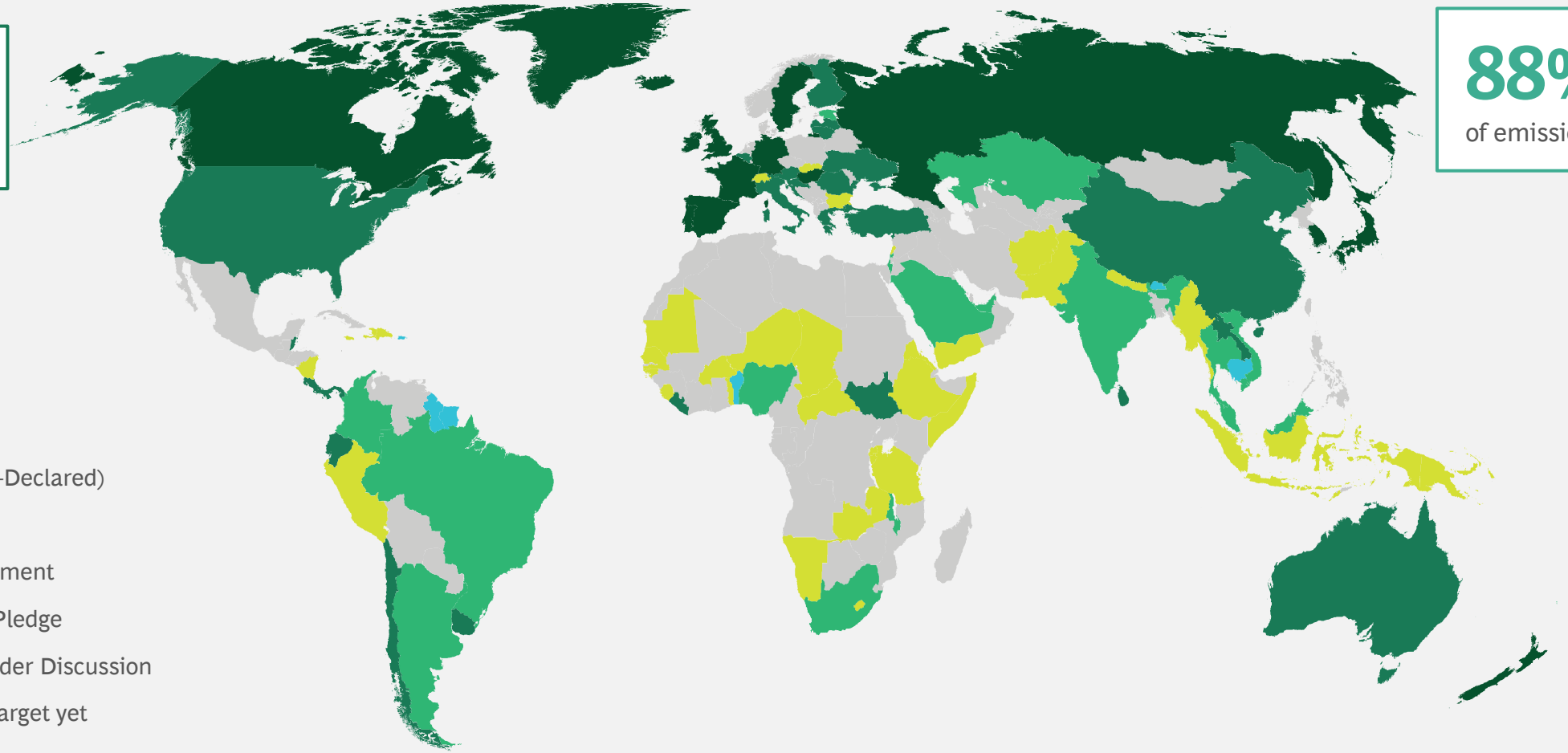
90% of world's GDP has committed to Net-Zero pledges…

Countries with progress on Net-Zero pledges

As of Jun/2022

90%
of GDP

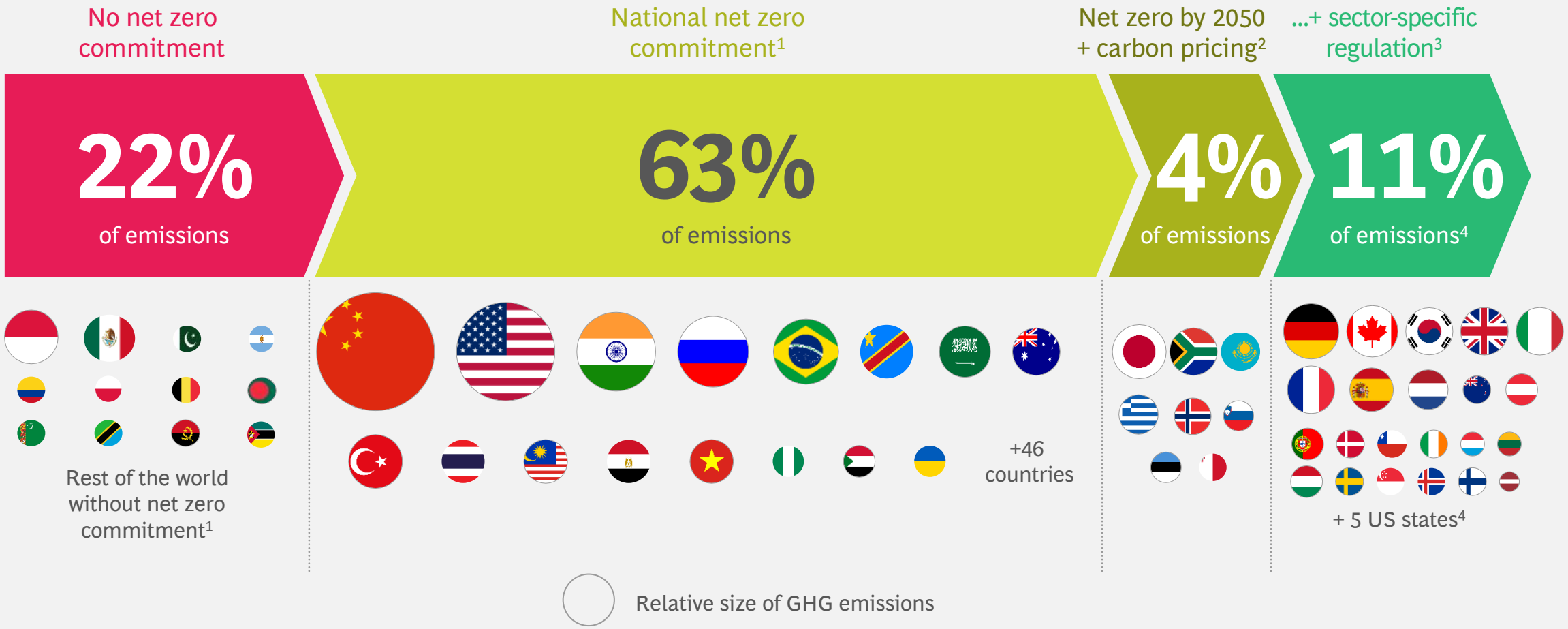
88%
of emissions



- Achieved (Self-Declared)
- In Law
- In Policy Document
- Declaration / Pledge
- Proposed / Under Discussion
- No Net-Zero Target yet

Note: National commitments independently of target date and that are considered sincere (either in law, in policy document, officially declared or achieved)
Source: ECIU 2021; Climate Watch (CAIT 2018); Net Zero Tracker; BCG analysis

… but large commitment-regulation gaps still remain

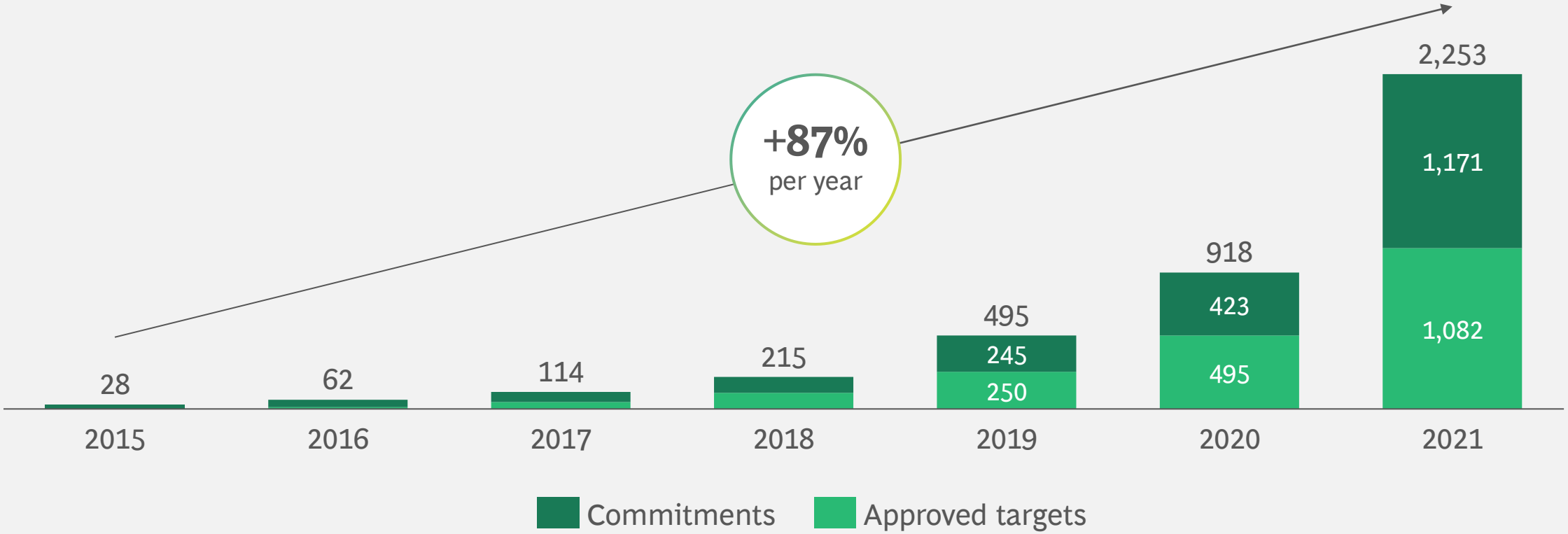


1. National commitments independently of target date and that are considered sincere (either in law, in policy document, officially declared or achieved); 2. Emissions trading scheme or carbon tax in place; 3. At least one regulatory instrument per sector: energy, agriculture, transport and industry; 4. Including emissions of 5 US states (California, Maine, New York, Virginia, Connecticut). Source: Net Zero Tracker; Climate Watch; ICOS; Ren21; Past Coal Alliance; ICCT; World Bank; Governments' websites; BCG analysis

Corporate commitments are growing exponentially…

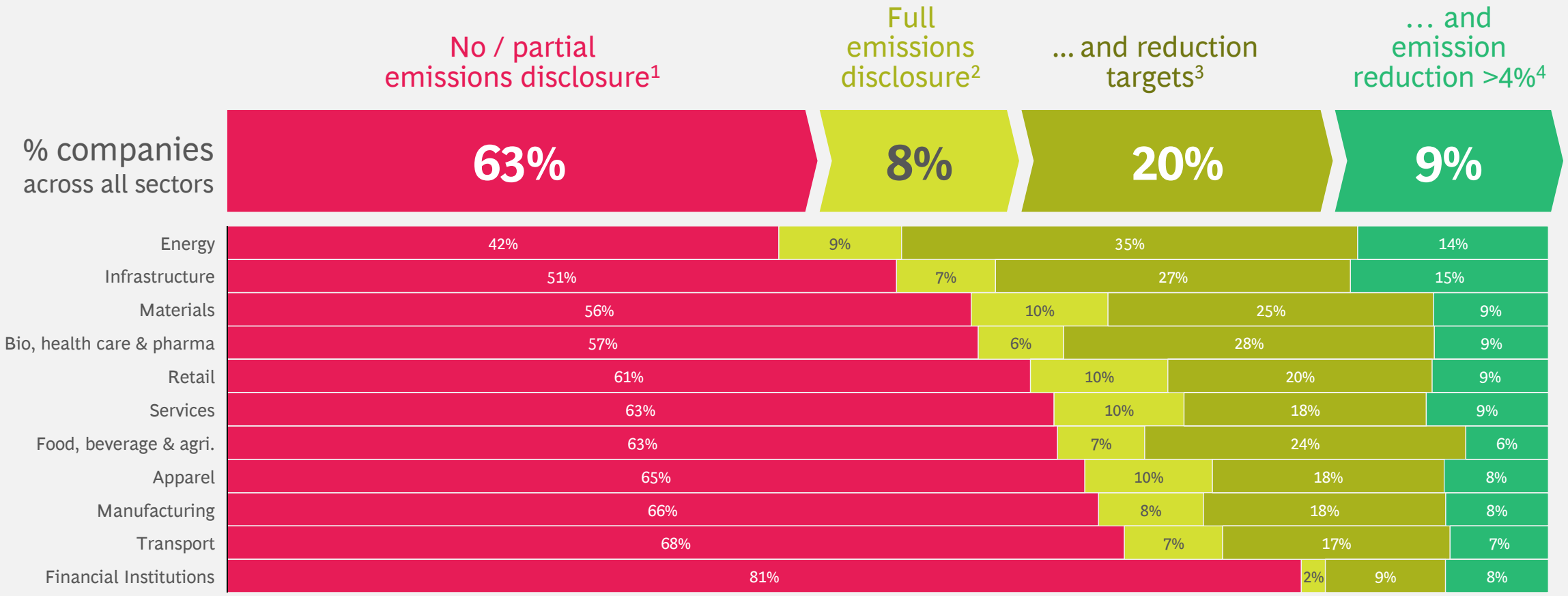
Companies with approved science-based targets and commitments[1]

Worldwide, 2015-2021



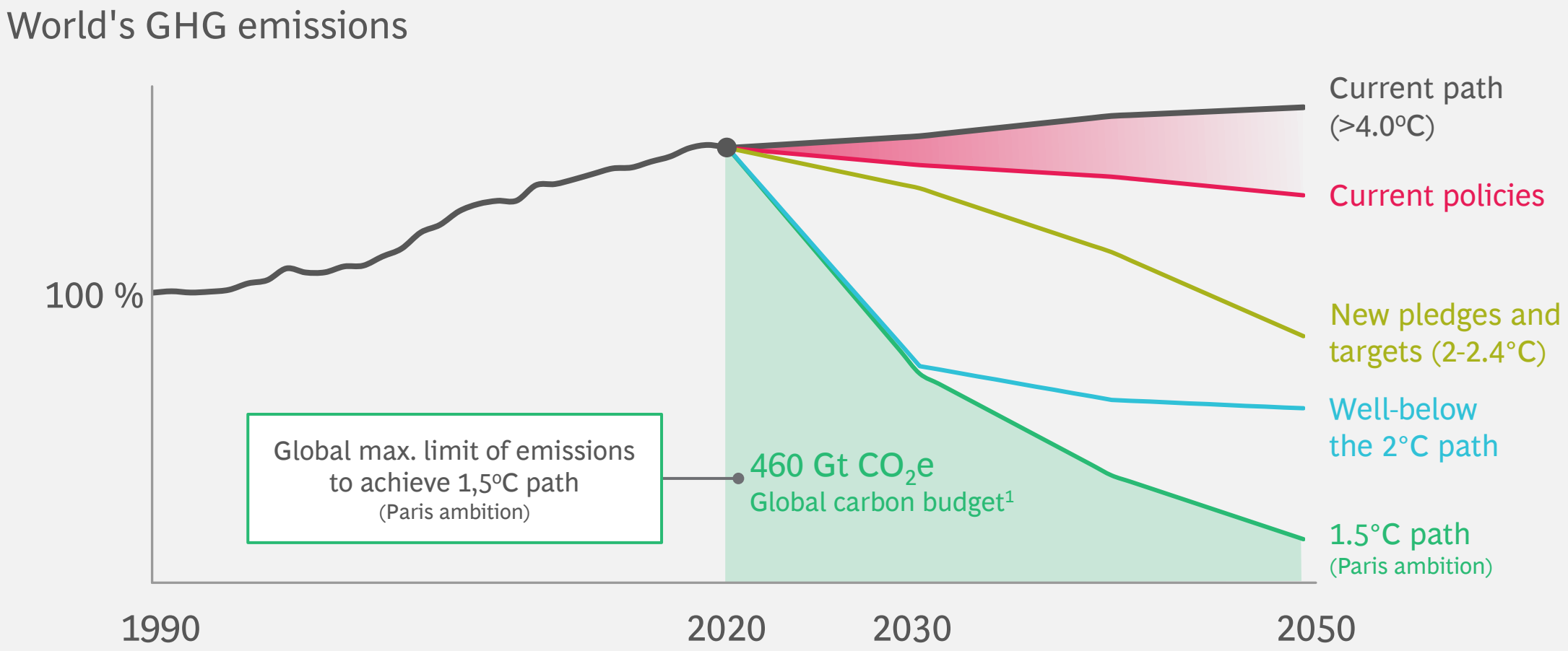
1. Cumulative view to the end of each year
Source: Net Zero Tracker; Science-Based-Targets initiative (SBTi)

… but corporate climate actions are still insufficient



1. Companies that don't disclose emissions data or disclose only (parts of) scope 1 and/or 2 emissions; 2. Companies that fully disclose scope 1+2+3 emissions; 3. Companies that fully disclose all emissions AND had an emission reduction target in 2019; 4. Companies that fully disclose all emissions, had an emission reduction target in 2019 AND reduced emissions '18 vs. '19 by >4%
Source: CDP data [2018-2020]; Refinitiv data [2018-2020]; BCG analysis

Significant emission gaps remain for 2030 and 2050…



1. Carbon budget refers to the cumulative amount of CO_2 emissions permitted under a period of time to stay below a certain temperature
Source: Carbon Brief; Carbon Tracker; IEA; Reuters

… and every 0.5ºC increased will have a huge marginal impact

going from 1.5°C to 2°C increases significantly the magnitude of climate change consequences

- **Up to 50% more people** exposed to increase in **water stress**
- **Sea rise on average of extra ~10cm,** resulting in damage or destruction of small islands
- Up to **several hundred million more people** exposed to severe climate risks (inc., extreme weather) and **poverty**
- **Global fishery decline of another 1.5Mt,** demonstrating marine damage and risking food poverty
- **Coral reef decline of as much as 99%,** putting marine environments at severe risk

Source: IPCC report

Transition to NZ will require massive investments over next three decades

Scale of change

in numbers

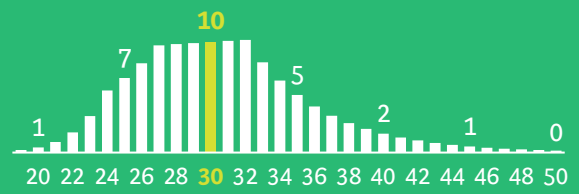
$100-150T

Total climate-aligned accumulated investments for the next 3 decades

$3-5T

Avg. annual investments in 2020-50 (peak of $10T per year around 2030)

Global Climate Financing Need (US$ T)



- Investment is expected to be highly frontloaded until 2035

Non exhaustive

Investments pursue Climate Solutions at scale (some of which are already viable)

+ Commercially viable -

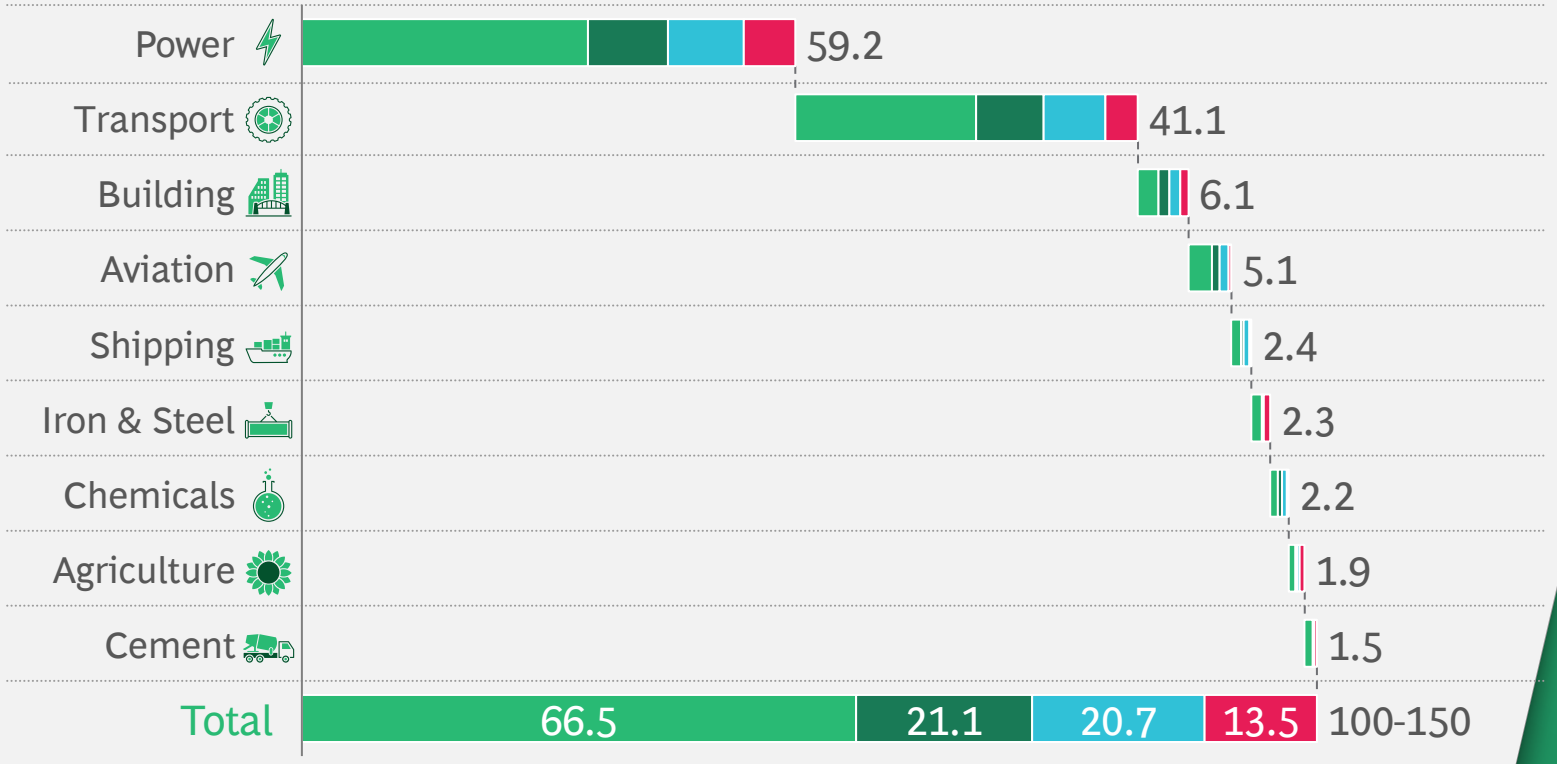
- Renewable energy
- Biomass & biofuels
- Sustainable agriculture
- NBS (carbon offset)
- Electrification & batteries
- Green Hydrogen (enabling low-carbon steel/cement)

Source: GFMA and BCG Report – Climate Finance Markets & The Real Economy Dec/2020; BCG analysis

Trillion-dollar investments expected to reach all sectors & regions worldwide

Investment needs per sector

Worldwide, cumulative for period 2020-50, in US$ T



1. Rest of the world
Source: Climate Finance Markets BCG Report 2020

Power & transport are the sectors with highest investments needs

Asia is the region with highest investment needs

Capital will target multiple Climate solutions, such as:

- Electrification & batteries
- Renewable energy
- Biofuels & Biomass
- Sustainable agriculture
- Carbon capture and NBS
- Green Hydrogen (enabling low-carbon steel/cement)

…

15.8 Gt emissions per annum, ~30% global emissions

72%	6%	22%
Coal	Oil	Natural gas

~$59T estimated investment needed globally over 2020-2050

Sectors involved by lever: Energy; Power transmission & distribution

	Sectors involved by lever	Core Climate trends associated	Needs heavy subsidy – Commercially viable
$39T	**Increase reliance on renewables** • Higher upfront capex investment for renewable plants with long-term savings on maintenance and opex • Solar PV and onshore wind remain the most viable and prominent energy sources; ongoing efforts to broaden off-shore wind beyond the North Sea	Renewable Energy	• LCOE at parity today in several regions; key bottleneck around supply variability
$17T	**Improve grid flexibility & reliability** • Build new network connections/lines (e.g., north/south lines help mitigate seasonality) • R&D for emerging technologies to support variable generation (e.g., energy storage), as well as off-shore grids and long-distance transmission	Energy Storage	• Storage still not utility scale today; technology for off-shore & long-distance transmission improving
$3T	**Invest in large-scale development of CCUS infrastructure (beyond NBS)** • Critical for markets with newer coal plants (e.g., China, South-East Asia) • Costs can be reduced through "hub" approach where shared infrastructure can support multiple sectors	Carbon Capture, Usage & Storage	• Limited commercial viability, need for high carbon price or policies and incentives for large-scale deployment

US$6.2T expected to be invested in the developing world

Source: IEA; IRENA; ETC; BN EF; Capital IQ; Dealogic; BCG analysis

HEAVY ROAD TRANSPORT

2.2 Gt emission per annum, ~4% global emissions

83%	17%
Medium and heavy-duty trucks	Light commercial vehicles

~$32T estimated investment needed globally over 2020-2050
(of which ~$28T required for purchasing FCEV and BEV commercial vehicles)

Sectors involved by lever (Auto[2], Trucking, Energy, Chemicals)		Core Climate trends associated	Needs heavy subsidy – Commercially viable
$1.1T	Develop and produce battery electric commercial vehicles[1] • Investment in R&D, conversion/construction of factories to manufacture BEVs and components	Electrification & Battery Renewable Energy	• Proven technology; dependent on battery cost and density and availability of charging infrastructure
$16.4T	Purchase battery electric commercial vehicles to replace or expand fleet • Technology most relevant for intra-city transport and light commercial vehicles		
$0.8T	Develop and produce fuel cell electric commercial vehicles[1] • Investment in R&D, conversion/construction of factories to manufacture FCEVs and components	Green H_2	• New technology w/ maturity expected ~2030; high price of fuel cell stack ($100-150k) today; undeveloped H_2 economy
$11.8T	Purchase fuel cell electric commercial vehicles to replace or expand fleet[1] • Technology relevant for inter-city and medium & heavy-duty commercial vehicles due to distance, weight and power requirements		
$1.8T	Expand production of hydrogen; build out hydrogen refueling infrastructure[1] • Investment in hydrogen refueling network, including distribution and retail • Need for PPPs and industry JVs to foster simultaneous growth in demand and supply	Green H_2	• H_2 production nascent & expensive today; refueling stations small in number, expansion dependent on FCEV adoption
$0.2T	Use of biofuels and synthetic fuels • Biofuels: scale biodiesel production and biomass supply; tackle cross-industry competition • Synthetic fuels: scale Green H_2/e-diesel production infrastructure (excl. capex in renewables)	Biofuels & Biomass Green H_2	• Biodiesel: increasing use expected in medium-term (~2030) • Synthetic: long time to maturity w/ tech. in concept state

Other decarbonization levers

Use of autonomous driving to improve fuel efficiency; better supply chain optimizations
- Reduce fuel consumption by platooning, accommodated by autonomous driving; technology expected to be ready for highway use in 2030
- Optimize utilization and supply chain efficiency through better route planning, asset utilization, etc.

US$2.1T expected to be invested in the developing world

1. Includes: CVs used for transport of goods (LCV, MDT, HDD and excludes pure off-highway vehicles (agriculture, construction, etc.),buses, cars and LCVs not used for transport of goods; 2. auto and components (excl. motorcycles)
Note: Electric charging infrastructure and buses not considered in the heavy transport sector but will be considered in the light transport sector
Source: EEA; European commission; WRI; FAO; IEA; IHS Markit; ETC; ACEA; OICA; Hydrogen Council; NREL; ICCT; the Royal Society; ESU-Services; Capital IQ; BCG Analysis

LIGHT ROAD TRANSPORT

3.9 Gt emission per annum, ~7% global emissions

Passenger vehicles	Buses and minibuses	Light commercial vehicles	Two/three wheelers
77%	11%	8%	4%

~$9T estimated investment needed globally over 2020-2050

Sectors involved by lever (Auto[2], Ground transportation, Energy)		Core Climate trends associated	Needs heavy subsidy — Commercially viable
$3.6T	**Develop/produce electric light duty vehicles (excl. two/three wheelers)[1]** • Investment in R&D, conversion/construction of factories to manufacture BEVs and components • Battery development & production estimated at ~15-25% of investment in long-term • In addition, financing for purchase of BEVs estimated at ~$51T	Electrification & Battery Renewable Energy	• Fast-evolving technology, with battery prices expected to decrease in near term; BEVs expected to achieve TCO parity with ICE by 2024 in some regions
$0.2T	**Develop and produce battery electric 2/3 wheelers** • Investment in R&D, conversion/construction of factories to manufacture electric 2/3 wheelers and components • Electric two/three-wheeler market expected to be concentrated in China, India and the ASEAN region. In addition, financing for purchase of electric 2/3 wheelers ~$2.9T	Electrification & Battery Renewable Energy	• Fast-evolving technology, moderate dependency on expansion of public charging infrastructure as private charging mostly used
$1.2T	**Expand public electric charging infrastructure** • Investment in public slow and fast charging stations • Need for public intervention to foster simultaneous investment in supply of charging infrastructure and demand for electric vehicles. In addition, investment in private slow charging infrastructure:~$0.8T	Electrification & Battery Renewable Energy	• Recharging stations prevalent in some regions but further expansion needed with greater BEV adoption
$4.0T	**Mode shift to mass transit** • Financing of public transportation infrastructure (e.g., buses, trains) • Lead to significant returns from savings in vehicle ownership, savings in operating and fuel costs from reduced vehicle use, along with travel time and congestion savings	Sharing Economy	• Prevalent technology; further expansion needed especially in regions with high/or increasing levels of urbanization

US$1.9T expected to be invested in the developing world

1. Excludes all LCV used for the transport of goods; 2. Auto and components (incl. motorcycles) Note: Hydrogen refueling infrastructure not considered in the light transport sector but considered in the heavy transport sector. Source: EEA; European commission; World Resources Institute; FAO; IEA; OICA; Energy Transitions Commission; ICCT; Coalition for Urban Transitions; IHS Markit; UN; Market Research Future; Capital IQ; wattev2buy; Evobsession; Gasgoo AutoNews; Cleantechnica; SinaAuto; Xinhuanews; Yiche, ifeng; BCG analysis

3.9 Gt emissions per annum, ~7% global emissions

55%	20%	19%	6%
Space heat	Water heat	Cooking	Other

+ Scope 2 emissions from through consumption of electricity by the huge army of electrical devices used in buildings (e.g., lighting, air conditioners, heat pumps, appliances, etc.) provide an additional 6.8 Gt of CO_2

~$6.1T estimated investment needed globally over 2020-2050
(in addition, ~$4.6T estimated for residential investments made by retail consumers, excluded from analysis)

Sectors involved by lever (Real Estate Investors)		Core Climate trends associated	Needs heavy subsidy / Commercially viable
Residential $0.4T Commercial $3.4T	**Increase efficiency of electric equipment** • Advanced high-efficiency lighting, appliances and cooling systems to reduce energy demand; sensors and controls for electrical equipment to further reduce energy consumption	Electrification & Battery; Energy Efficiency	• Cost-effective, commercially available technology; continued R&D required
Residential $0.5T Commercial $1.0T	**Reduce heating/cooling demand with advanced building envelope design** • High performance windows, insulation, sealing, etc. to reduce heat loss; reflective surfaces, passive solar design, etc. to reduce cooling needs • Includes investment for low-energy new builds and to refurbish existing structures	Energy Efficiency; Smart Cities	• Viable technology with short payback periods; however, limited adoption due to lack of awareness and downtime caused by renovations
Residential $0.2T Commercial $0.5T	**Replace conventional heating with advanced, low carbon tech. and electrification** • Condensing boilers, high-efficiency gas-fired water heaters and high-efficiency biomass heaters to reduce energy consumption in the near-term • In the long-term, widespread adoption of high-performance electric heat pumps and solar thermal technology	Biofuels & Biomass; Renewable Energy	• Viable and cost-effective options; more advanced technology (e.g., cold climate and small-scale heat pumps) require further R&D
Residential $0.03T Commercial $0.05T	**Develop system-level district heating/cooling** • Investment to improve efficiency of older systems and/or shift energy supply to heat waste or renewable energy • Additionally, development of new systems in priority areas	Energy Efficiency	• Viable in areas with major urban development or high heat density • Requires access to waste heat or renewable energy
Residential <$0.01T	**Shift to higher efficiency cooking technologies** • In developing countries, a shift from traditional biomass to more efficient technologies (e.g., advanced biomass cook stoves) • R&D required to improve efficiency of modern electric cooking appliances	Energy Efficiency	• Commercially available, however significant CAPEX and OPEX costs

US$1.0T expected to be invested in the developing world

1. Private equity and pension funds are also important investor group; assumed funding structure: NA (25% equity, 75% loans); Asia and Europe (40% equity, 60% loans)
Source: EEA; European commission; World Resources Institute; FAO; IEA Transition to Sustainable Buildings; IEA Energy Technology Perspectives; ETC Mission Possible Building Heating; CAIT; NAREIT; NCREIF; RCA; National Association of Realtors; RERC; KPMG; Bank of International Settlements; Federal Reserve of St. Louis; PERE News; Capital IQ; BCG analysis

0.9 Gt emissions per annum, ~2% global emissions

Passenger: Narrowbody	Passenger: Widebody	Passenger: Regional	Freight: Dedicated	Freight: Belly
43%	37%	6%	7%	7%

~$5.1T estimated investment needed globally over 2020-2050

Sectors involved by lever: Airlines, Energy

Lever	Sectors involved by lever	Core Climate trends associated	Needs heavy subsidy – Commercially viable
$0.2T	**Improve efficiency of fleet** • Improvements related to engines, aerodynamics, weight and control systems to enhance efficiency • Replace fleet with new gen. aircraft and/or retrofit technology (estimate excludes purchase of new fleet (~$4.5T), considered BAU, will require agreed-to transition pathways and thresholds)	Energy Efficiency	• Majority of technologies are developed and mature
$0.9T	**Use Sustainable Aviation Fuels (SAF)** • Biofuels: build facilities and scale capacity; feedstock supply constraint must be solved to ensure long-term viability • Synthetic fuels: scale infrastructure to produce green hydrogen and e-fuels (estimate excl. renewables investing) • Development is dependent on partnerships between players in entire fuel value chain	Biofuels & Biomass; Green H_2	• Biofuels: HEFA pathway most economical near-term option, but biofuels still at 2-8x A1 prices • Synthetic fuels: Not yet commercially viable (2-5x A1 prices); long time horizon for development and relies heavily on renewable energy prices
$4.0T	**Deploy aircraft with next generation propulsion technologies** • Next-gen propulsion systems: open rotor, hybrid-electric, full electric and hydrogen combustion (estimate excludes R&D investment) • Full electric likely only for short-haul due to limited energy density	Green H_2; Energy Efficiency	• Nascent technologies; expected entry into service: propfan (2030); hybrid (2035); full electric (2040); hydrogen combustion (2040)

Other decarbonization levers

Upgrade air traffic management systems
- Optimize flight distance, climb/descent profiles and enhance airport operations

Demand management in passenger aviation
- Reduce global passenger aviation demand (e.g., through behavioral changes, phasing out short-haul flights and reducing long-haul flights and flights for business purposes)

US$0.3T expected to be invested in the developing world

Source: EEA; European commission; World Resources Institute; FAO; IRENA; ICCT; ICAO; Energy transformation committee; IATA; Airbus; IEA; The Royal Society; Oliver Wyman; Capital IQ; BCG analysis

0.9 Gt emissions per annum, ~2% global emissions

23%	19%	13%	45%
Container ships	Bulk carriers	Oil tankers	Other ship classes

~$2.4T estimated investment needed globally over 2020-2050

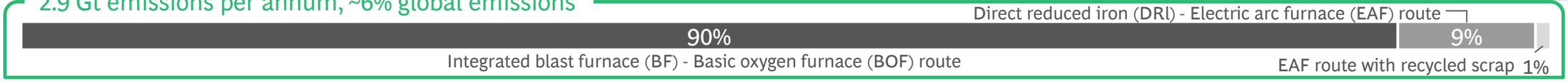
Sectors involved by lever: Marine Freight Transport, Energy, Chemicals

		Core Climate trends associated	Needs heavy subsidy – Commercially viable
$0.6T	**Improve ship efficiency** • Investment to implement technologies related to drag reduction, exhaust treatment and power systems in global fleet • Several technologies require R&D with commercial readiness in short-medium term (R&D capex not considered in investment estimate)	Energy Efficiency	• Some technologies available today, while others need further development in medium-term
$0.1T	**Improve operational efficiency** • Digital solutions to optimize routing, speed, engine, energy systems, hull performance • Will require measurement and enforcement of decarbonization outcomes to ensure alignment with decarbonization pathways • Technologies under development by large marine players	Artificial Intelligence; Energy Efficiency	• Relatively new concepts, being tested in market
$1.7T	**Use fuel alternatives** • Financing for vessels with new fuel sources (e.g., engines and on-board storage) • Investment in land-based infrastructure(e.g., H_2, fuel production and storage facilities) needed for ammonia, H_2, or e-methanol as alternative zero-carbon fuel • Estimated capex split: H_2 production ~$0.7T (assumed for O&G sector), Ammonia synthesis/ storage/ distribution ~$0.7T (Chemicals), on-board engines & storage ~$0.2T (Marine Freight)	Green H_2; Biofuels & Biomass	• E-ammonia, H_2 or e-methanol: not viable, needs heavy incentives and policies to support

US$0.2T expected to be invested in the developing world

Source: EEA; European commission; World Resources Institute; FAO; IRENA; ICCT; UNCTAD; Energy transformation committee; Shell; OECD; Henics Shipping News; UMAS; IEA; Norton Rose Fulbright; Capital IQ; BCG analysis

2.9 Gt emissions per annum, ~6% global emissions



~$2.3T estimated investment needed globally over 2020-2050

Sectors involved by lever (Energy / Iron & Steel)		Core Climate trends associated	Needs heavy subsidy – Commercially viable
$0.7T	**Increase use of recycled scrap** • Primary steel production via BOF can use scrap for up to 30% of metallic input, however secondary steel production from 100% scrap requires EAF • Significant investment required to fund large scale shift to EAF process • Estimate does not include recycling infrastructure investment needs	Waste management; Circular economy	• Cost-effective materials and technology • Dependent on investment in collection and sorting infrastructure, particularly in developing countries
$1.0T	**Use natural gas as a reducing agent for virgin steel production** • Requires DRI-EAF, which only accounts for ~8% of global virgin steel production today and requires funding for large scale process shift • Adoption dependent upon access and price of natural gas • Useful as transition solution to reduce GHG emissions	Green H_2; Renewable energy	• Proven technology, however, OPEX higher at ~115% of BF-BOF route • Carbon capture technology needed to achieve net zero emissions
$0.1T	**Switch to H_2 based reduction for virgin steel production** • Potential to substitute up to ~30% coal with H_2 in BF-BOF, or 100% of natural gas in DRI-EAF; investment required for H_2 electrolyzer • Adoption dependent on adaptation of electrolyzers for use in steel production, as well as price of renewable electricity	Green H_2	• Nascent technology with OPEX at ~145% of BF-BOF route • Expected to scale with cheaper availability of green hydrogen
$0.5T	**Retrofit plants with carbon capture, use & storage (CCUS), beyond NBS** • Steel sector will require investment to retrofit plant equipment • Additional early-stage financing required for CO_2 capture R&D and infrastructure for transportation and storage	Carbon Capture, Usage & Storage	• New technology in steel industry that is not adopted at large scale • Estimated >$90/t carbon price needed for economic viability

US$0.8T expected to be invested in the developing world

Source: EEA; European commission; World Resources Institute; FAO; ETC Mission Possible; IEA Energy Technology Perspectives; Global Costs of Carbon Capture and Storage Institute; Journal of Cleaner Production; Capital IQ; BCG analysis

2.2 Gt emissions per annum, ~4% global emissions

Ammonia	Bulk chemicals (i.e., high volume petrochemicals like Ethelyne, Propelyne)	Hydrogen & synthesis gas	Nitric Acid	Other
29%	48%	11%	6%	6%

~$2.2T estimated investment needed globally over 2020-2050

Sectors involved by lever (Chemicals)		Core Climate trends associated	Needs heavy subsidy – Commercially viable
$0.2T	**Improve process and energy efficiency of chemical production** • Significant room to reduce energy loss through better heat recovery systems, plant redesign to enable local heat transfer/capture • Opportunity to increase efficiency of industrial steam systems	Energy Efficiency	• Plant redesign, heat transfer/capture & steam system tech are more nascent compared to equipment upgrades
$0.9T	**Use alternative, lower-emission fuels and feedstocks** • Use of electrification or renewable feedstocks/fuels (e.g., biomass) requires upfront investment to prepare plants for scaled production • Green H_2 and NH_3 production most mature; expected to require large portion (~60%) of investment • Electrification of steam crackers & bio-based chemicals need further R&D	Biofuels & Biomass Green H_2	• Higher costs when compared to conventional feedstocks; potential supply constraints
$1.1T	**Deploy CCUS technology (beyond NBS)** • Investment to retrofit plant equipment • Blue hydrogen (H_2 production w/ CCUS) expected to need large portion (~30%) of investment	Carbon Capture, Usage & Storage	• Proven technology for blue H_2 and blue ammonia, however not cost-competitive at scale; • Practical application for other chemicals in nascent stages

US$0.2T expected to be invested in the developing world

Source: IEA; Ammonia Energy; Bloomberg; EPA; European Commission; BCG analysis

5.4 Gt emissions per annum, ~10% global emissions

42%	23%	12%	10%	13%
Enteric fermentation	Manure	Fertilizer	Paddy rice	Other
Microbes in the digestive tract, or rumen of livestock producing methane	Substantial amounts of nitrous oxide & methane	Over usage of nitrogen fertilizers	Bacteria producing methane	Energy and machinery use

~$1.9T estimated investment needed globally over 2020-2050

Sectors involved by lever: Food & Beverage, Farming

		Core Climate trends associated	Needs heavy subsidy — Commercially viable
$1.3T	**Shift diets toward alternative proteins (plant-based and cultured-meat)** • Investment to increase capacity for production and distribution of artificial/plant-based meat to replace 30% of meat in 2050 • Imperative to drive change in consumer demand and dietary trends	Alternative Proteins	• Existing presence in mainstream restaurants and groceries; several new players and incumbents entering market, but still "less affordable than traditional options"
$0.5T	**Improve manure management** • Infrastructure (e.g., anaerobic digester- AD) for farmers to reduce GHG emission from manure (storage and handling) and produce biogas • 3rd party ownership (investment, operation) emerging as an option • Key to consider other ESG dimensions like animal welfare	Sustainable Farming; Biofuels & Biomass; Low-carbon meat	• Proven technologies; upfront investment to finance infrastructure; farming currently lacking scale for >75% of farmers
$0.1T	**Adopt regenerative agriculture, specifically no-till farming** • Financing new machinery for farmers for no-till farming • Long-term impact of this technology is still debated	Carbon Credit; Sustainable Farming	• Split-incentive problem: benefits for landowners in long-term; effort needed from farmers

Other decarbonization levers

- Apply other regenerative agriculture processes and practices (e.g., crop rotations)
- Reduce food waste (33% of all the food produced goes to waste from production, transportation to storage)
- Reduce enteric fermentation through animal feed, methane food pills (e.g., 3-nitro-oxypropan)
- Adopt fertilizers with increased Nitrogen Use Efficiency

US$0.6T expected to be invested in the developing world

Source: FAO report; U.N.'s "The State of Food and Agriculture; IPCC; IATP reports; Soil health institute reports; USDA Economic Research Service And National Agricultural Statistics Services; Rural and Agriculture finance - state of the sector report; BCG analysis

2.3 Gt emissions per annum, ~4% global emissions

Direct emissions (Calcination process to produce clinker)	Indirect emissions (Energy used to heat kilns)	Other (Powering other machinery)
50%	40%	10%

~$1.5T estimated investment needed globally over 2020-2050

Sectors involved by lever: Cement

	Lever	Core Climate trends associated	Needs heavy subsidy – Commercially viable
$1.1T	**Invest and grow CCUS (beyond NBS)** • Retrofit plants with post-combustion and oxy-fuel solutions • CCUS can be retrofitted to existing cement plant equipment; however, technologies are expensive and in nascent stages of development (e.g., no commercial scale pilots of oxy-fuel)	Carbon Capture, Usage & Storage	• CCUS needs a high carbon tax to be commercially viable in the cement industry (estimated >$100/t$CO_2$)
$0.3T	**Upgrade to + equip new plants w/ high-quality, energy-efficient equipment** • Newer plants include solutions like Excess Heat Recovery (EHR) technology to improve energy efficiency • Solutions are available commercially; policies on emissions caps can motivate producers	Energy Efficiency	• Policies on emissions caps can further motivate cement producers to implement energy-efficient equipment
$0.1T	**Increase use of alternative fuels to produce thermal energy** • 70% of thermal energy at plants today is powered by coal; opportunity to recycle biomass and use alternative fuels for energy • Requires amenable legislation and waste management policies to enable redirect of waste from landfills for burning to produce energy	Biofuels & Biomass; Waste management; Renewable Energy; Green H_2	• Already in use today; typically requires minimal retrofits to existing kilns
	Increase use of alternative binders to reduce clinker ratio • Alternative binders can be used to reduce clinker, subject to regional availability; ongoing R&D into novel cements • Natural alternatives (e.g., volcanic ash) are subject to regional availability, and by-products (e.g., fly-ash & slag) are dependent on industrial production and regulation	-	• Some natural alternatives and industrial by-products are in use today; novel cements are in nascent stages of development

US$0.3T expected to be invested in the developing world

Source: IEA; Material Economics; ETC Mission Possible; Global Carbon Capture Institute; BCG analysis

Brazil is already ahead in key Climate Solutions at scale

~85%

of power matrix is already renewable (~600 TWh), vs. ~26% world (it's where most G20 nations wish to be in 2030-40)

~17 Mn

Hectares of ILPF[1] already exist in Brazil as of 2020 (almost ~2x the size of Portugal)

~36 Mn

Hectares of No-till farming already exist in BR as of 2020 (equivalent to the size of Germany)

Up to **~10%**

lower GHG footprint in BR Cement (vs. world avg.), annually avoiding >2 Mt CO_2e (equivalent to >500,000 cars)

Up to **~30%**

lower GHG footprint in BR Steel (vs. world avg.), annually avoiding >30 Mt CO_2e (equivalent to >7,000,000 cars)

~75%

of car fleet in BR adherent to biofuels in 2020 (for full-cycle, ethanol emits ~45g vs. ~150g CO_2e/km for pure gasoline)

1. Refers to Crop-Livestock-Forest Integration System

Source: Energy Atlas; OntarioTech University; US Environmental Protection Agency; IEA Agency; CNI; IPEA; ILPF; EMBRAPA; press release; expert interview; BCG analysis

Looking forward, Brazil is well-positioned to become a global enabler of decarbonization solutions at scale…

Carbon Credits

BR is #1 country globally in reforestation potential, holding ~10% of world's NBS mitigation potential (up to 1 Gt CO_2e per year)

- Reforestation & Restoration
- Avoided forest conversion

Clean Energy

85% of BR Power Matrix is renewable (vs. 26% world); High potential & low costs on wind/solar/biomass can enable energy solutions

- Renewable Energy
- Biomass & Biofuel
- Green H_2

Sustainable Agriculture

#1-2 exporter of many food products (soy, orange juice, sugar, meat, corn), BR can scale-up its RegAg. by >5x (currently at 20+ Mn Ha)

- Biological Fertilizers
- Regenerative Agriculture
- Low-carbon protein

Green industrial products

BR industries benefit from natural resources, cleaner power and biodiversity to supply low-carbon goods, at scale, to the world

- Low-carbon basic items (e.g., Steel, Cement…)
- Green BR Industrial products

Carbon credits

Brazil can be the main Carbon Sink of the planet

Carbon Credits market aims to mitigate GHG emissions & is expected to reach US$1T by 2028

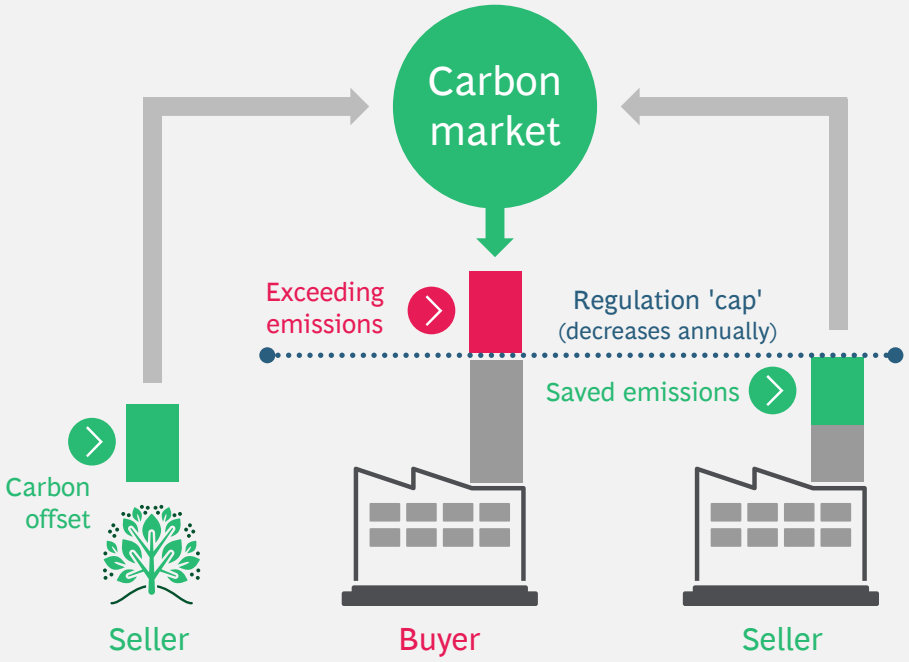
~35% of GHG mitigation by 2030 is expected to come from cost-effective Nature-Based Solutions (~11 Gt CO_2e/yr)

BR is the #1 nation in NBS mitigation potential (0.6-1.0 Gt CO_2e per year cost-effectively)

Carbon credit markets are a mechanism to mitigate GHG emissions & can reach US$1T before end of this decade

How do emission trading systems work?

To avoid paying carbon taxes, buyer can acquire missing credits either from saved emissions credits from other players or from offset credits from specialized projects

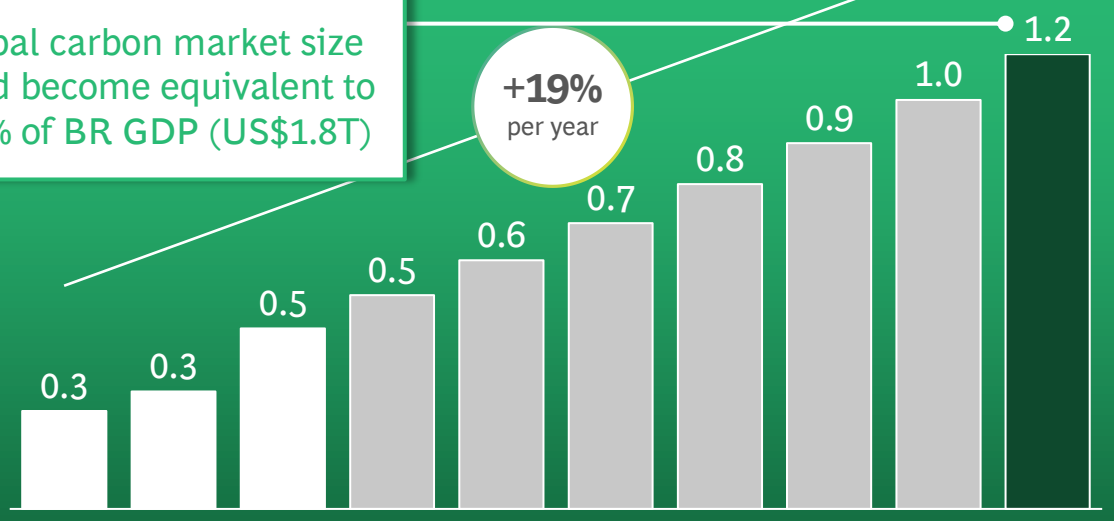


Global carbon credit markets value[1] (US$ T)

Preliminary

Global carbon market size could become equivalent to ~70% of BR GDP (US$1.8T)

+19% per year



	2019	2020	2021	2022e	2023e	2024e	2025e	2026e	2027e	2028e
Avg. volume (Gt CO_2e/yr)	~11	~13	~16	~17	~17	~17	~18	~18	~19	~19
Avg. price (US$/t CO_2e)	~24	~24	~29	~34	~38	~42	~47	~51	~56	~60

1. Considers both carbon allowances and carbon credits
Source: CLP carbon credits, Trove Intelligence, Bloomberg NEF Projections, Forest Trends, Verra, Gold Standard, ACR, CAR, UN IPCC, Refinitiv, Financial Express, BCG analysis

Carbon markets | Two types of carbon markets

COMPLIANCE OR REGULATED

Markets for carbon credits created by the need to comply with a regulatory act

Emission trading system (ETS)

- Also referred to as cap-and-trade programs
- The 'cap' on GHG emissions declines annually to achieve the climate policy targets of its jurisdiction or members
- Allowances are freely allocated or auctioned to companies which can then 'trade' allowances to comply with the cap on their emissions
- Companies with low emissions can sell their extra allowances to larger emitters

VOLUNTARY

Corporations, governments and individuals volunteer to offset their emissions by purchasing carbon credits

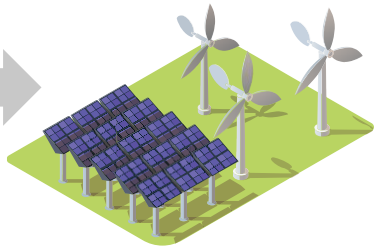
Carbon credits/offsets

- Generated by projects that avoid, reduce or remove GHG emissions beyond a business-as-usual scenario
- Projects include reforestation, improved forest management, wetland restoration and renewable energy
- Traded by individuals and companies on the voluntary markets (though some carbon credits can also be used in select compliance markets)
- Majority of projects follow rules established by independent standards bodies

Source: Carbon Credits Educational Magazine; BCG analysis

Carbon markets | How carbon markets work

1 A carbon offset represents one metric ton of carbon emissions (CO_2e) that is avoided by completing an activity in a less carbon-intensive way



2 Carbon offsets are generated, for example, from renewable sources (like wind or solar) instead of fossil fuels (like coal or gas)

3 This process requires a third-party auditor to come and ensure that a project resulted in avoidance of CO_2 and other GHG in line with International Protocols

4 Carbon credits are issued by registered entities based on opinion of third-party auditor and their internal quality checks.

5 Carbon credits are issued when registered entities confirm "avoidance of GHG" by the project

6 These carbon emissions avoided can be allocated to an individual or business through their purchase of a carbon credit

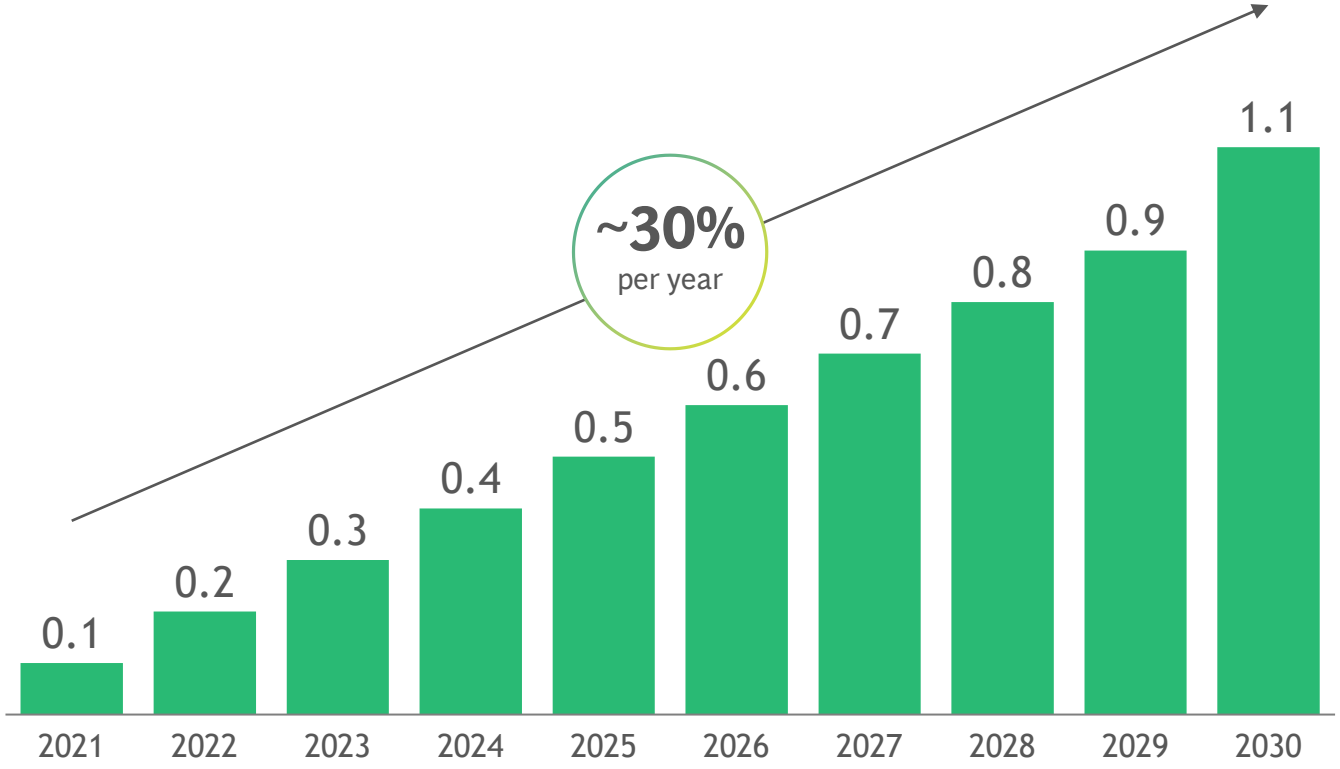
7 Once an individual or a business purchases a carbon credit, it is transferred to buyer for use

Source: Carbon Credits Guide; BCG analysis

Carbon markets | Carbon offset demand is expected to grow 30% per year

Carbon offsets demand

Gt CO_2e/year



Factors affecting demand

1. **Investor Pressure**
   Bold net-zero pledges driven by increasing pressure from investors and consumers is driving demand for carbon credits
2. **Better Organized Markets**
   Improvements in accounting practices, ethics and compliance policies drive better organization in carbon markets, and easier purchases
3. **Regulation Change**
   Regulatory changes in individual compliance markets significantly impact demand for particular offset credits (e.g., CORSIA)
4. **Customer Preferences**
   Dynamic buyer preferences drive volatility in demand for different credit types, pushing advancements across many different solutions
5. **Quality Benchmarks**
   Persistence of 'lower quality' credits from when market was less stringent pulls down average prices. However, introduction of higher quality drives up demand

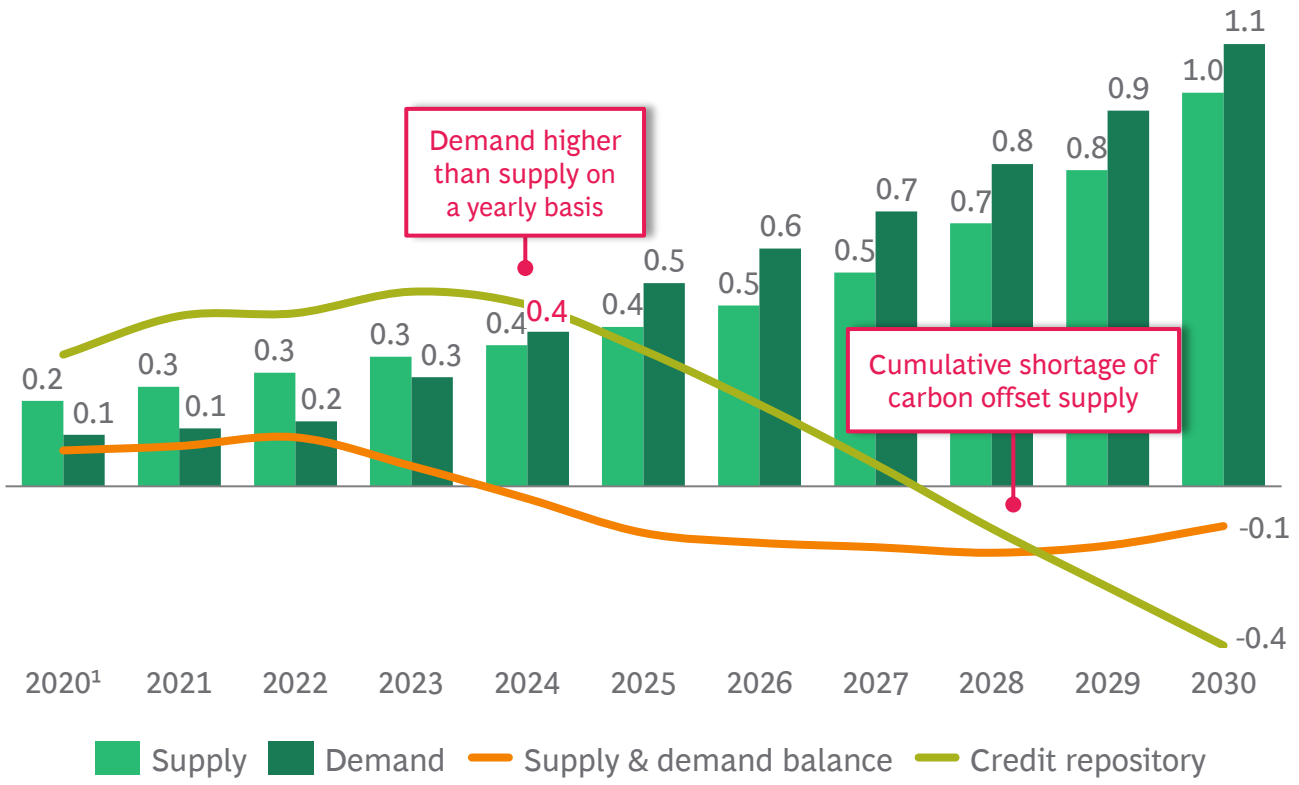
Direction of impact: Up | Up and down

1. Actual. All others expected. Note: Company demand includes California CAR and other smaller geographical compliance offset demand; Top-down scenario = demand of ~7Gt CO_2e/year required to meet 1.5° pathway. Source: Registries (Gold Standard, ACR, CAR); CORSIA; IMO; IEA; CDP; Company commitments; ICAP; Fraunhofer ISI; BCG analysis

Carbon markets | Offset market is expected to reach supply shortage by 2028

Demand & supply for Carbon offsets in Gt CO_2e/year

Worldwide, forecasts in GtCO_2e per year



Despite significant supply potential for carbon offsets, existing supply structure is sub-scale with larger players, such as South pole, only able to supply up to ~20Mt CO_2e p.a. today

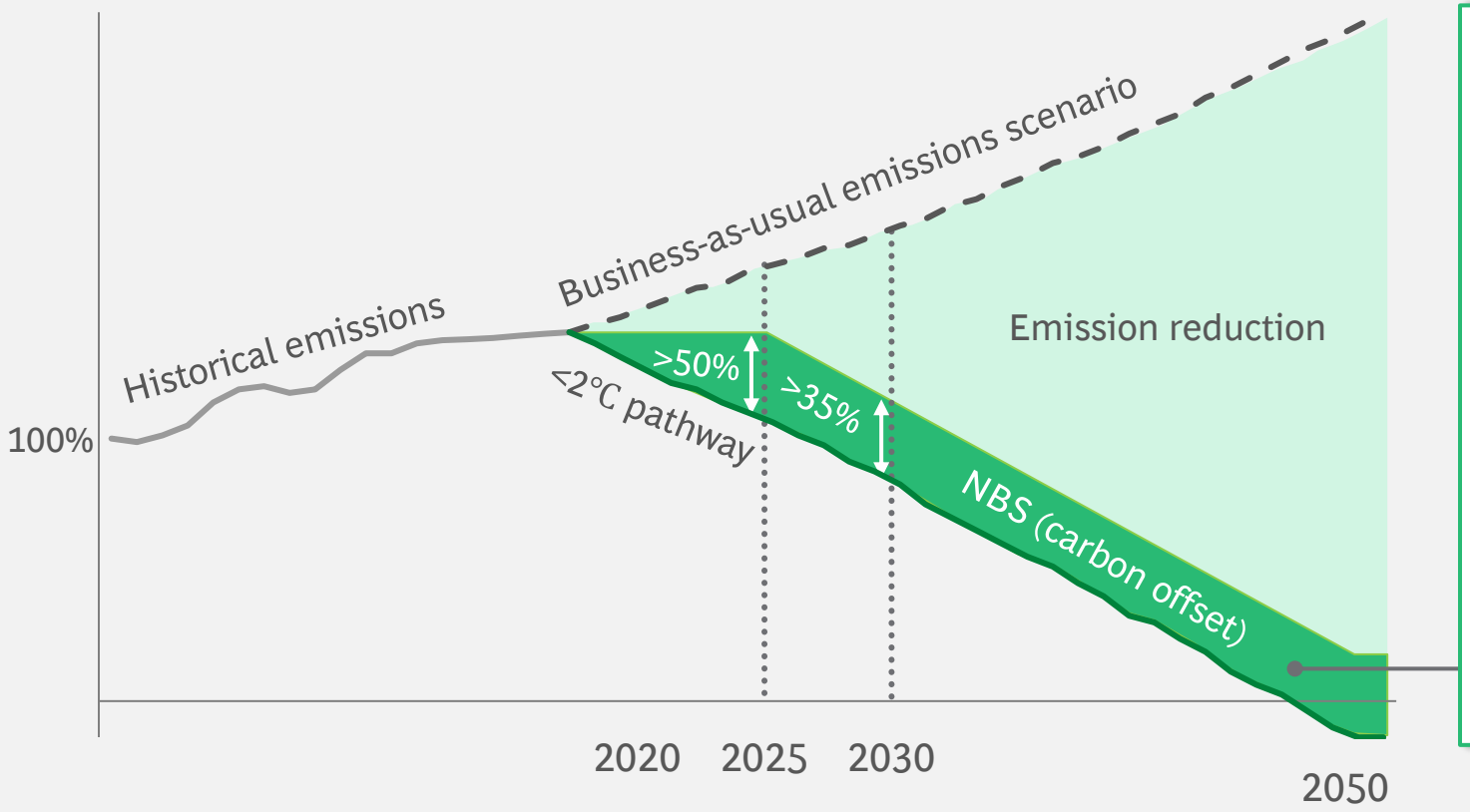
Industry survey[2] conducted with carbon credit marketplaces and developers show that the current market supply is expected to grow by maximum 10-20% CAGR until 2030

Current supply is expected to scale to maximum ~1Gt by 2030, leading to a sizeable short market between 2024-2030

1. Actual. All others expected.; 2. Industry survey was conducted with 10 executives on supply outlook between 2020-2040;
Note: Includes only VERs; products certified for compliance markets excluded (e.g., Gold Standard CERs, ACR & CAR offsets with ARB approval)
Source: Forest Trends; Verra; Gold Standard; ACR; CAR; UN IPCC; industry interviews; BCG analysis

Up to 35-50% of mitigations in the short-term will come from Nature-Based Solutions (NBS)

Global carbon emissions



NBS is a set of levers to compensate emitted GHG

Natural-Based Solutions (NBS) are the conservation, restoration & sustainable use of forests, agriculture and wetland

NBS projects are expected to be a key lever for mitigating GHG emissions and generating carbon offsets (and credits) in a cost-effectively manner

Source: Griscom et al (2017), BCG analysis

NBS | 9 key NBS levers that can mitigate GHG and generate carbon credits

Not exhaustive

Forest

Avoided forest conversion (REDD)
Halt conversion of native forests

Natural forest management
Apply forestation techniques to increase CO_2 content[1]

Reforestation & afforestation
Recover destroyed or plant new forests

Agriculture

Other soil sequestration
Apply cultivation techniques to avoid emissions[2]

Conservation agriculture
Plant cover crops when the main crop is not growing

Others[4]
Increase CO_2 stored in soil by alternative agriculture techniques[5]

Wetland

Avoided peatland impact
Halt degradation and/or loss of freshwater wetlands[3]

Peatland & coastland restoration
Recover destroyed freshwater wetlands through soil re-wetting, recover destroyed salt-water wetlands and plant mangroves

Others
Other recovery mechanisms, such as for halt degradation and/or loss of salt-water wetlands

1. E.g., extend harvest cycles, introduce alternate logging practices like cable winching, thin competing vegetation such as vines, optimize logging schedule; 2. Changes in cultivation practices, e.g., alternate wetting & drying & midseason drainage and residue & tillage management to avoid methane and N2O emissions; 3. E.g., to agricultural land or palm plantations; 4. Conservation agriculture technically one lever soil sequestration; 5. E.g., amending agriculture soil with biochar, sowing legumes in planted pastures, optimizing grazing intensity in pastures, planting trees in croplands without lowering agriculture production Source: BCG analysis

NBS | Definitions of NBS levers and techniques/measures they require

Avoided forest conversion (REDD)	• Emissions of CO_2 avoided by avoiding forest conversion • Forests defined as >25% tree cover
Reforestation & afforestation	• Additional carbon sequestration by converting non-forest (< 25% tree cover) to forest (> 25% tree cover) in areas where forests are the native cover type
Natural forest management	• Additional carbon sequestration in above- and below-ground tree biomass • Maximum potential requires timber harvests deferred for >50 years across all native forests currently under timber production. Wood production lost is made up by increased yields from improved plantations and additional wood production due to Reforestation • <USD 100 potential can be delivered by practices that continue and possibly increase timber production (e.g., reduced-impact logging, limited extension of harvest cycles)
Avoided peatland conversion	• Avoided emissions of above- and below-ground biomass and soil carbon due to avoided degradation and/or loss of freshwater wetlands
Avoided coastland convers. (blue carbon)	• Avoided emissions of above- and below-ground biomass and soil carbon due to avoided degradation and/or loss of salt-water wetlands (mangroves, salt marshes, seagrass beds)
Peatland restoration	• Avoided oxidation of soil carbon due to soil re-wetting in freshwater wetlands
Coastland restoration (blue carbon)	• Avoided oxidation of soil carbon and enhanced soil carbon sink due to soil re-wetting in mangroves, salt marshes, and seagrass beds • Additional sequestration also included for mangroves due to restored tree growth

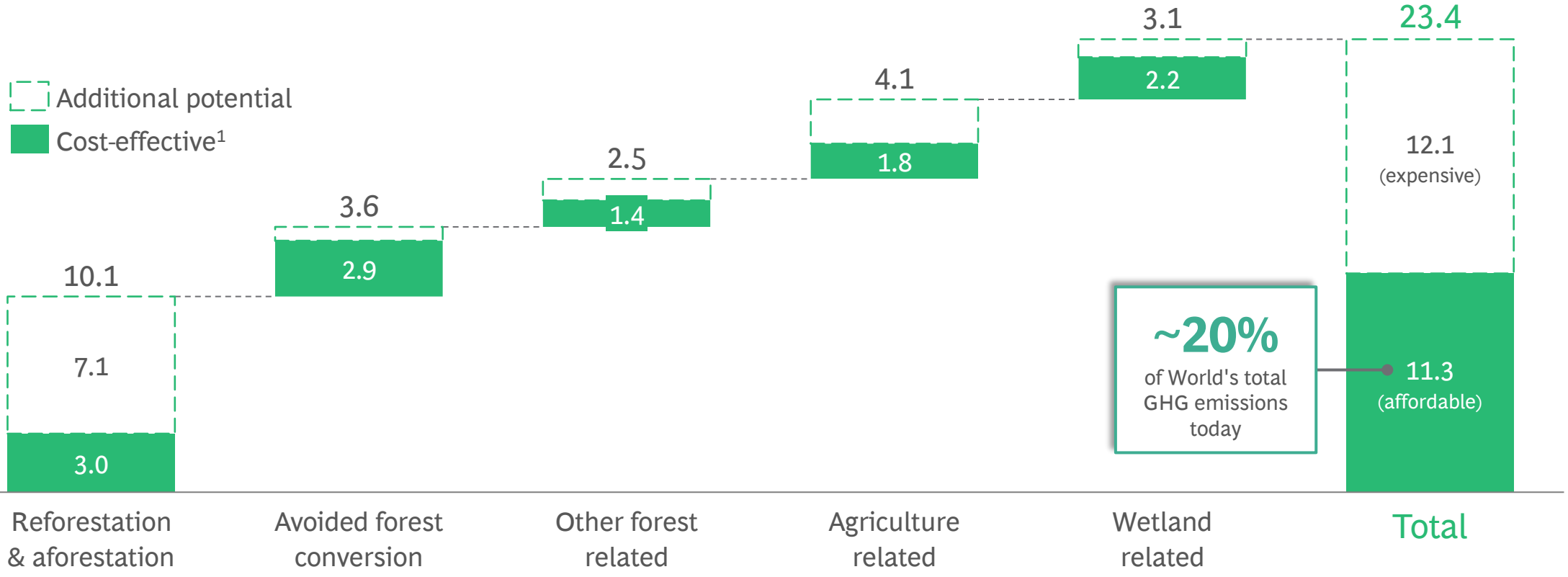
Conservation agriculture	• Additional soil carbon sequestration by planting cover crops during part of year when main crop is not growing • Suitable area excludes cropland already planted with a perennial or winter crop, and cropland where climatic factors and cropping systems require a fallow period or harvest is too late to allow cover crop planting
Improved rice cultivation	• Avoided emissions of methane and N_2O associated with anaerobic decomposition • Achievable by employing periodic draining of rice soils and removal of rice residues in flooded and upland rice production lands
Other alternative agric. techniques	• Biochar: Add. carbon sequestr. by amending agric. soils with biochar, which increases the agric. soil carbon pool by converting non-recalcitrant carbon (crop residue biomass) to recalcitrant carbon (charcoal) through pyrolysis. Source of biochar production limited to crop residue • Nutrient mgmt: Avoided N_2O emissions due to reduced fertilizer use and improved application methods on croplands • Trees in croplands: Additional carbon sequestration in above- and below-ground tree biomass and soil carbon due to integration of trees into croplands at levels that do not reduce crop yields. This includes windbreaks/shelterbelts, alley cropping, and farmer managed natural regeneration • Grazing intensity optimization: Add. soil carbon sequestr. on rangeland and planted pastures. Prescribes a decrease in stocking rates in areas that are over-grazed and an increase in stocking rates in areas that are under-grazed. Net result is increased forage offtake and livestock production • Legumes in pastures: Add. soil carbon sequestr. due to sowing legumes in planted pastures. Taking into account increases in N_2O emissions associated with planted legumes

Source: Griscom et al. 2017, Griscom et al. 2020, BCG analysis

NBS | World has potential to mitigate ~11 Gt CO_2e per year cost-effectively

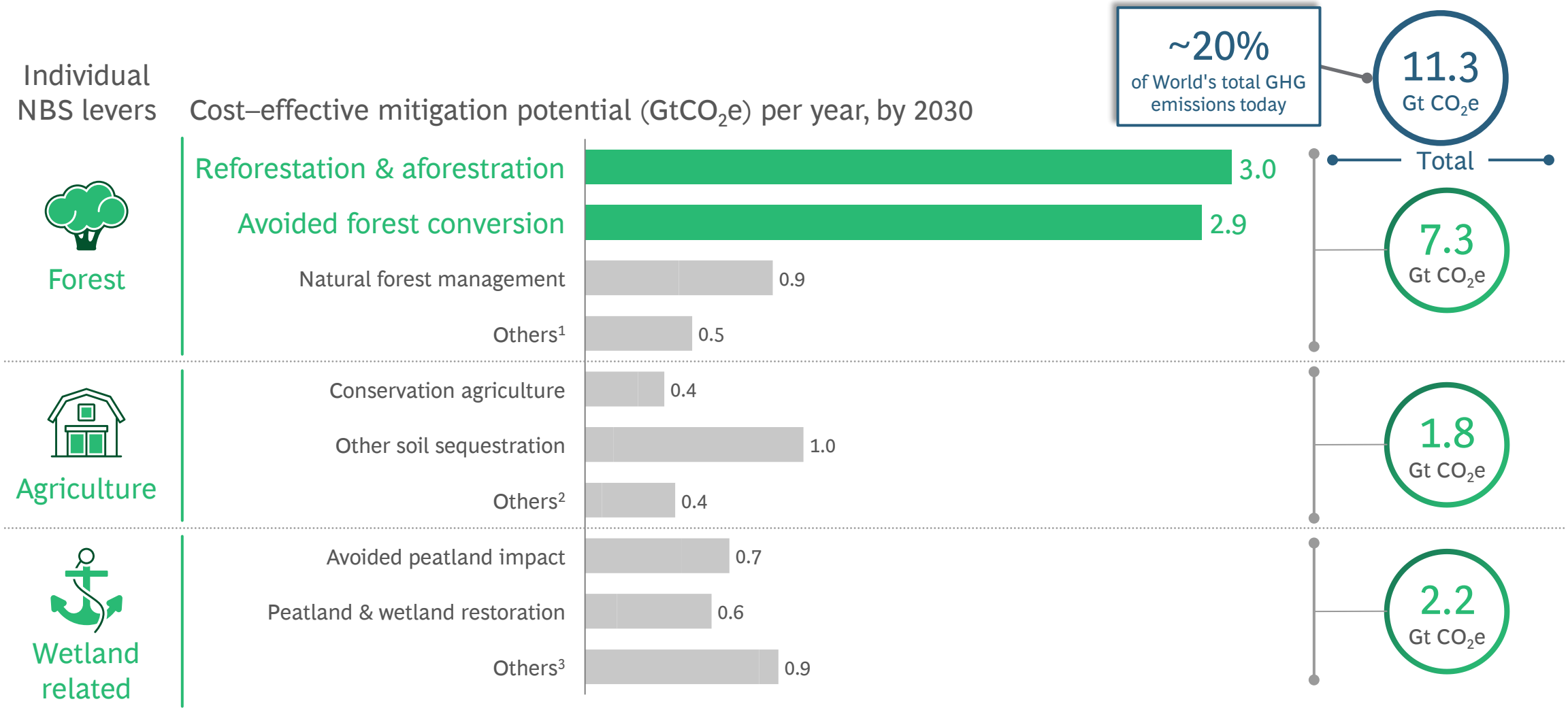
Cost-effective and additional potential for individual NBS levers

Worldwide, in Gt CO_2e per year



1. Cost-effective mitigation levels assuming a global ambition to hold global warming to <2 °C with cost <100 USD per tCO_2e yearly
Source: Griscom et al (2017), BCG analysis

NBS | Most of the ~11 Gt CO_2e/yr of NBS mitigation potential comes from Forests

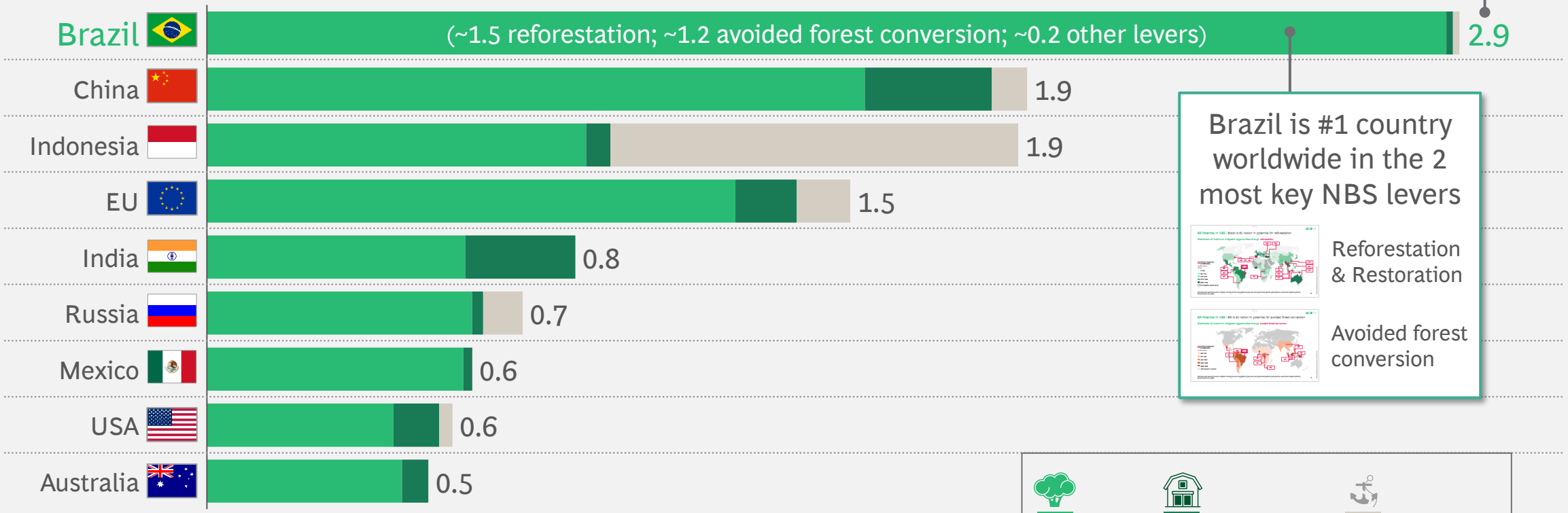


1. Including improved plantations, fire management, avoided wood fuel harvest, etc.; 2. Including improved feed, improved rice cultivation, and animal management, etc.; 3. Including cropland nutrient mix, avoided coastal wetland impact, etc.
Source: Griscom et al (2017), BCG analysis

Brazil is particularly well-positioned to supply NBS to the world at scale, leading the way on carbon offsets

Global max. potential for NBS levers in the main 8 countries and EU (in $GtCO_2e$ per year)

0.6-1.0
Gt CO_2e of cost-effective[1] potential per year in BR



Brazil is #1 country worldwide in the 2 most key NBS levers

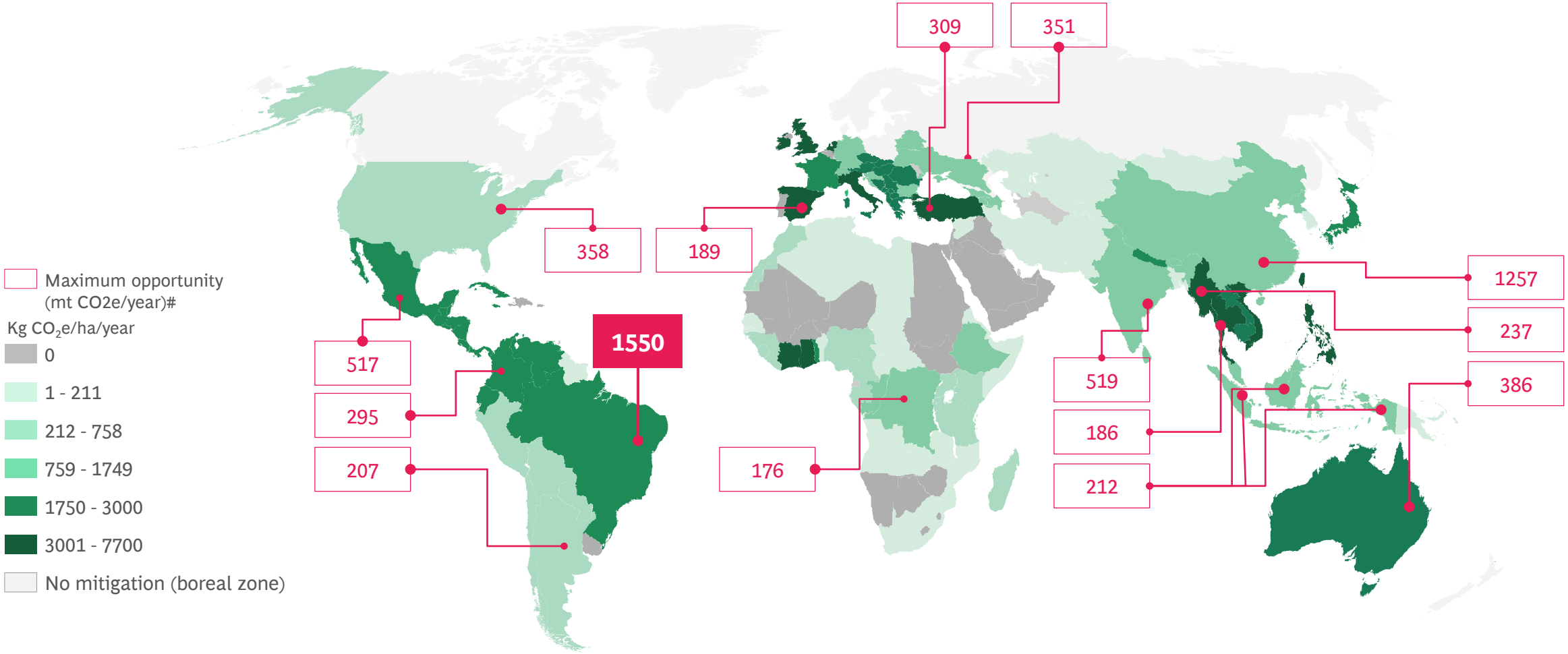
Reforestation & Restoration

Avoided forest conversion

1. Annual cost below 100 USD per tCO_2e mitigated or captured
Note: BR follows Griscom at al (Roe 2019's estimate for BR is ~2.5, also #1 worldwide)
Source: Griscom et al (2017), Roe 2019, BCG analysis

BR Potential in NBS | Brazil is #1 nation in potential for reforestation

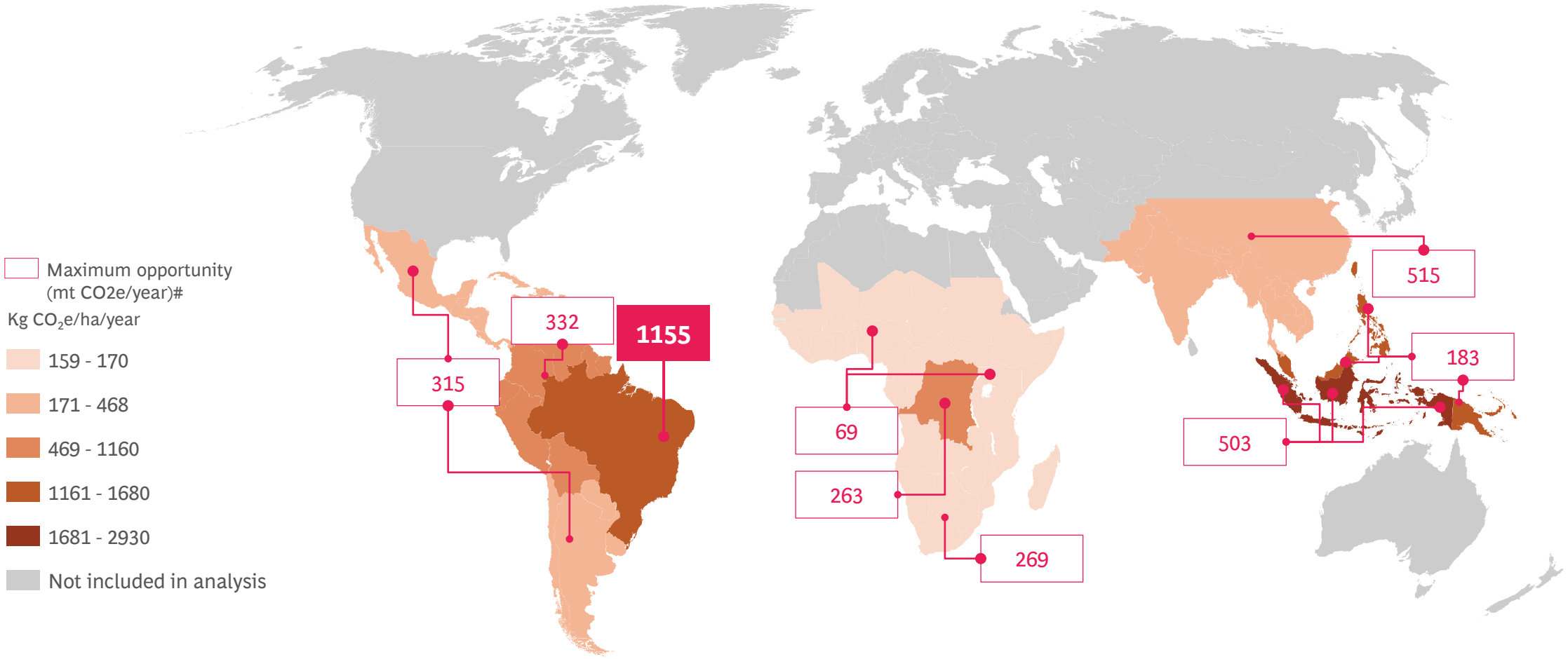
Distribution of maximum mitigation opportunities through reforestation



Note: Color code according to carbon mitigation intensity per area unity (kgCO_2e/ha/year). Call outs represent total potential (total potential > economical mitigation potential)
Source: Griscom et al (2017)

BR Potential in NBS | BR is #1 nation in potential for avoided forest conversion

Distribution of maximum mitigation opportunities through avoided forest conversion



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Source: Griscom et al (2017)

Clean energy

BR can supply the world with Clean Energy at Scale

BR has a relatively **clean Power & Energy Matrix,** reflecting a rich natural resources base

Brazil can lead the way to **enable cost-competitive Green H_2** at scale in the near future…

… and provide **biomass at scale** from today
(in BR, ethanol uses <3% of total productive land and represents ~20% of total energy matrix)

Brazil has a relatively clean Energy/Power Matrix versus world average, reflecting its rich natural resources base

BR is more renewable than rest of the world…

Share of renewables on:

	Energy Matrix	Power Matrix
World	Today ~14%; 2040 ~22%	Today ~26%; 2030 ~46%
Brazil	Today ~46%; 2040 ~50%	Today 80-85%; 2030 85-90%

… due to its rich natural resources base

Hydro potential: hydro contributes to ~12% of Brazil's current energy matrix and ~65% of its power matrix, helping companies on scope 2

Solar & Wind potential: Brazil clean energy production is estimated at ~5mn TJ, with potential to reach ~360mn[1] TJ by 2050

Biomass powerhouse: large agricultural potential coupled with National programs (e.g.: RenovaBio) boost the prevalence of biofuels (e.g., Ethanol in transportation)

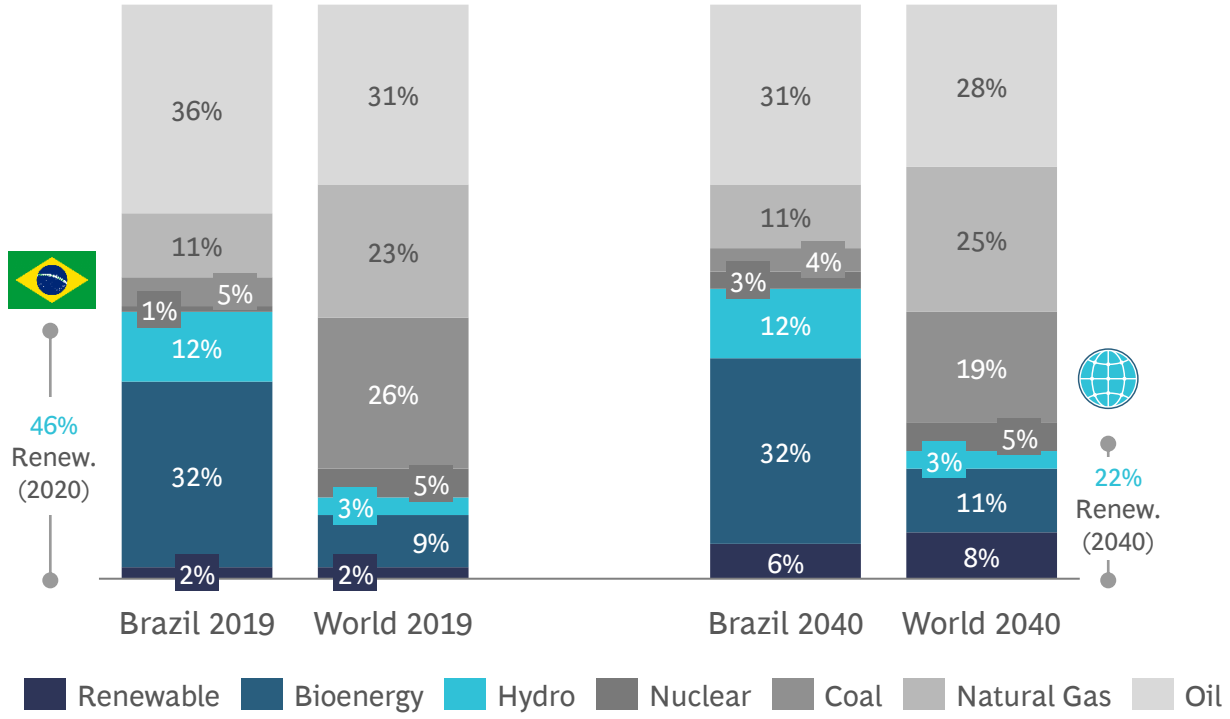
1. Potential for 2050 was calculated as continent potential multiplied by share of country area in the continent

Source: BP Energy Outlook, IEA World Energy Outlook 2020, Irena (2019), Statista, Plano Decenal de expansão de Energia 2031, BCG analysis

Energy | BR has a unique energy matrix, reflecting a rich natural resource base

Brazil has a high relative importance of Bioenergy/Hydro

Total primary energy demand Brazil vs RoW – Mtoe (IEA)



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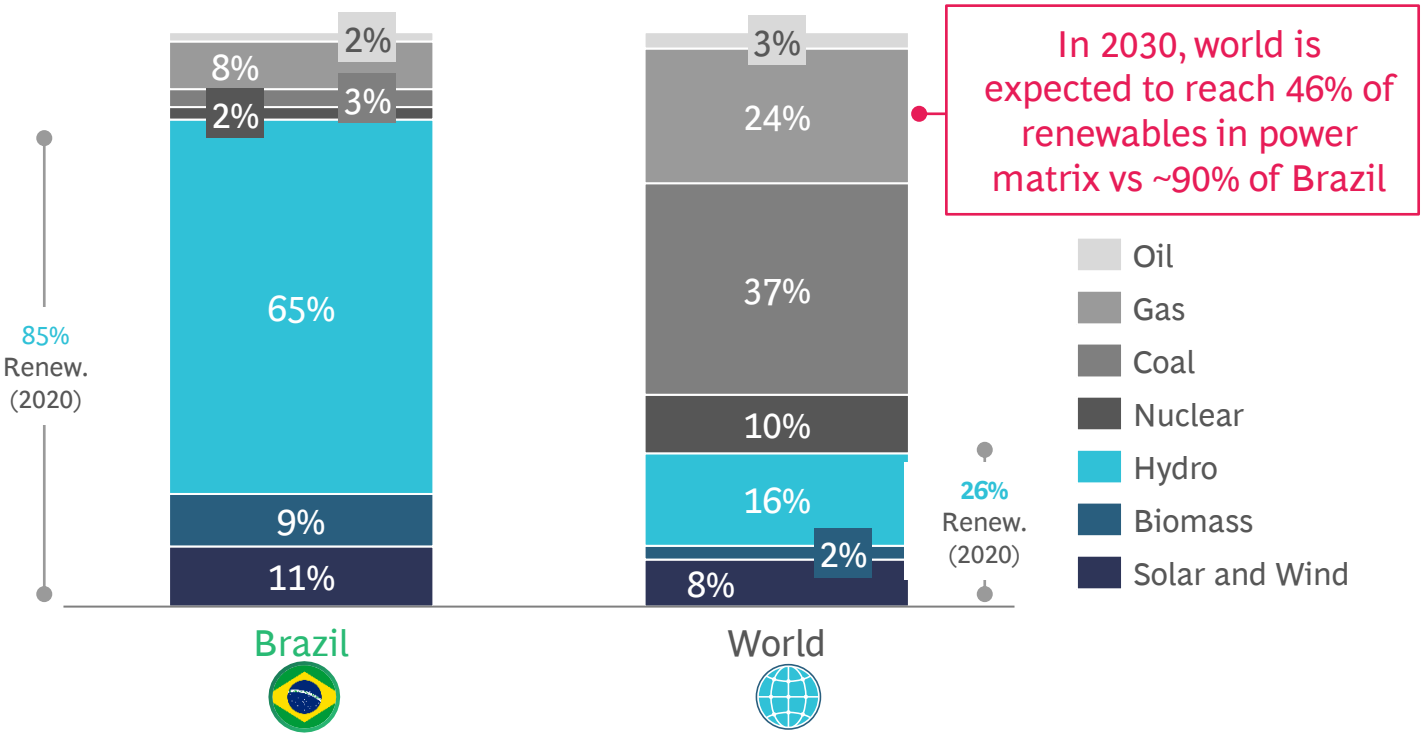
1. Potential for 2050 was calculated as continent potential multiplied by share of country area in the continent
Source: BP Energy Outlook, IEA World Energy Outlook 2020, Irena (2019), Statista, BCG analysis

Power | BR power matrix is 85% renewable…

Brazilian and Global power matrix (BEN and IEA, 2021) (%)

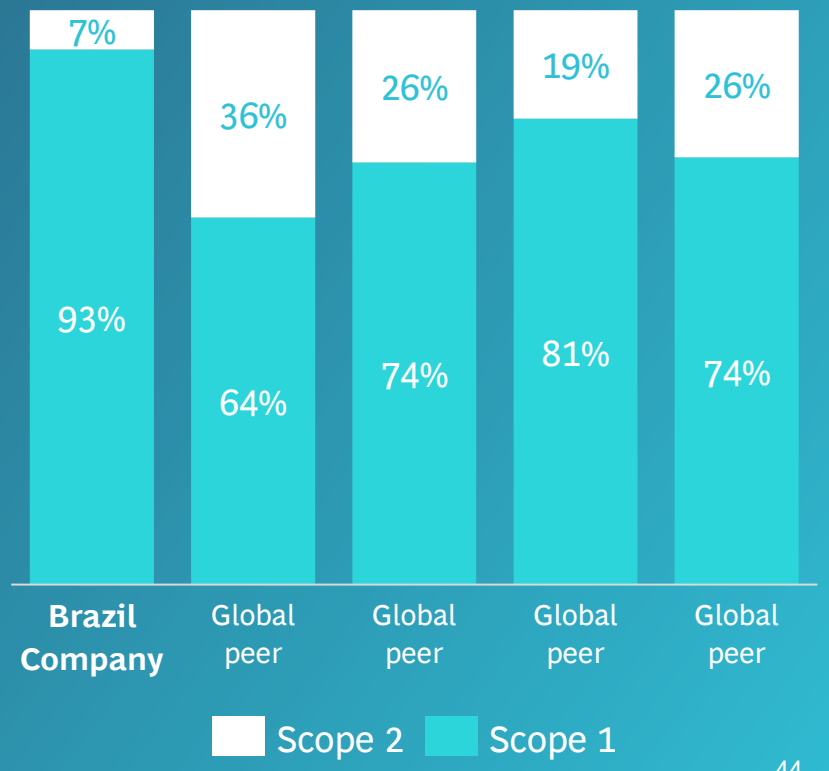


In 2030, world is expected to reach 46% of renewables in power matrix vs ~90% of Brazil

Note: Considers only centralized power generation connected to national grid (~85% of total power matrix).
Source: IEA, BEN, press search, Refinitiv ESG Database (July/21), company specific reports, BCG analysis

…which gives BR's private sector a head start in scope 2 emissions

Analysis performed for a specific Brazilian client Scope 1 & 2 emissions (% kg CO_2e/t)



Looking ahead, Brazil is well suited to lead Green H_2…

Key requirements to enable Green Hydrogen at Scale

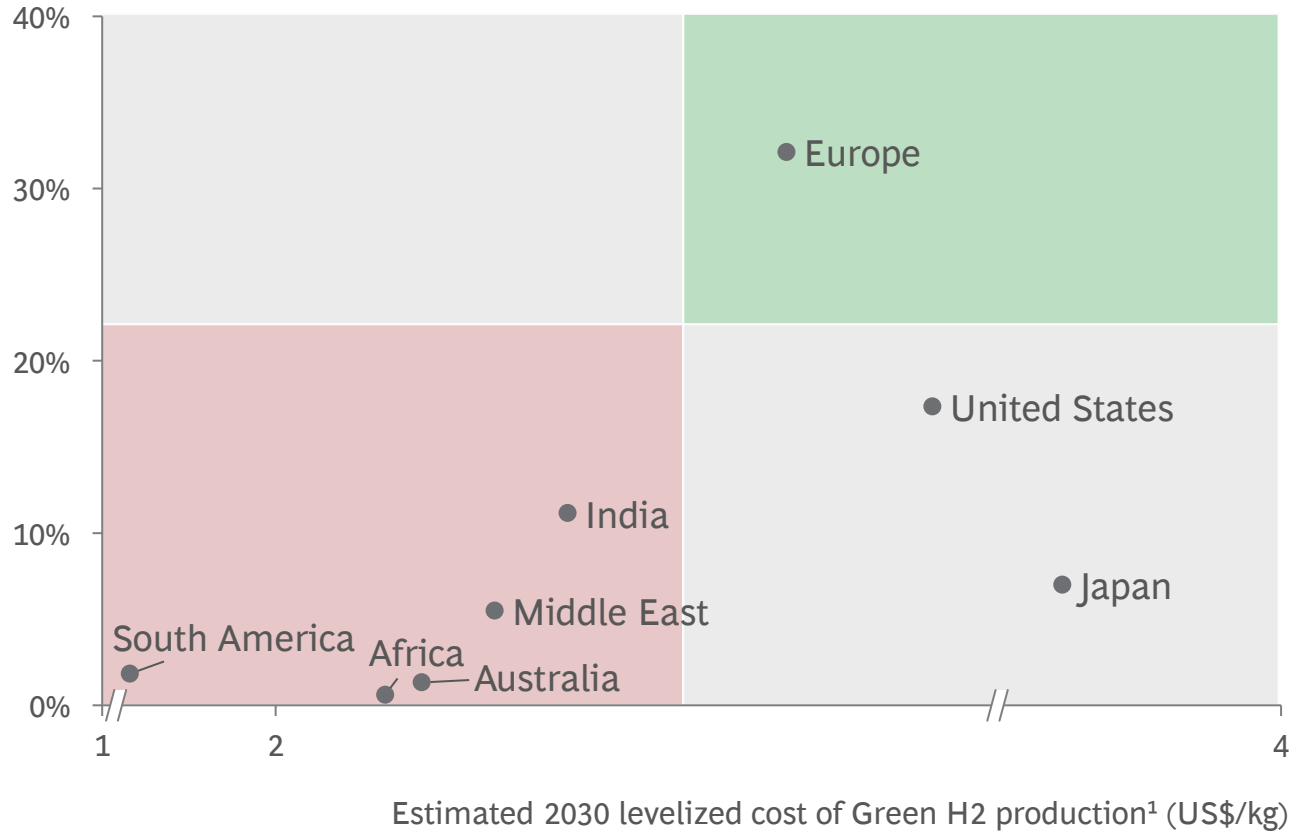
Non-exhaustive[1]

Leading countries	Cost-competitive 2030 (pre-incentives)	Cheap transport and end-price to key market 2030	Capacity to produce at scale
	✓ ~1.9 US$/kg	✓ ~3.5 US$/kg ~20 days — BR can also enable production + export of finalized goods	✓ ~360 EJ
	✓ ~1.7 US$/kg	✓ ~3.3 US$/kg ~25 days	≈ ~25 EJ
	≈ ~2.2 US$/kg	≈ ~4.0 US$/kg ~34 days	✓ ~1500 EJ — High solar incidence and wind potential
	✓ ~2.1 US$/kg	✓ ~2.5[2] US$/kg <4 days	≈ ~75 EJ
	≈ ~2.2 US$/kg	≈ ~4.0 US$/kg ~19 days	≈ ~15 EJ

1. Countries shown were prioritized as key potential Green H_2 hubs for having low renewable energy costs 2. Morocco end-price considers transportation by pipeline to Europe Note: Potential for 2050 per country was calculated as continent potential multiplied by share of country area in the continent. Source: BCG analysis

✓ Fits requirements ≈ Partially fits requirements

Green H_2 requirements | Europe will likely be a massive importer of Green H_2…



Recent announcements further indicate Europe's intention to import Green H_2 until 2030

European Commission

Press release | 18 May 2022 | Brussels

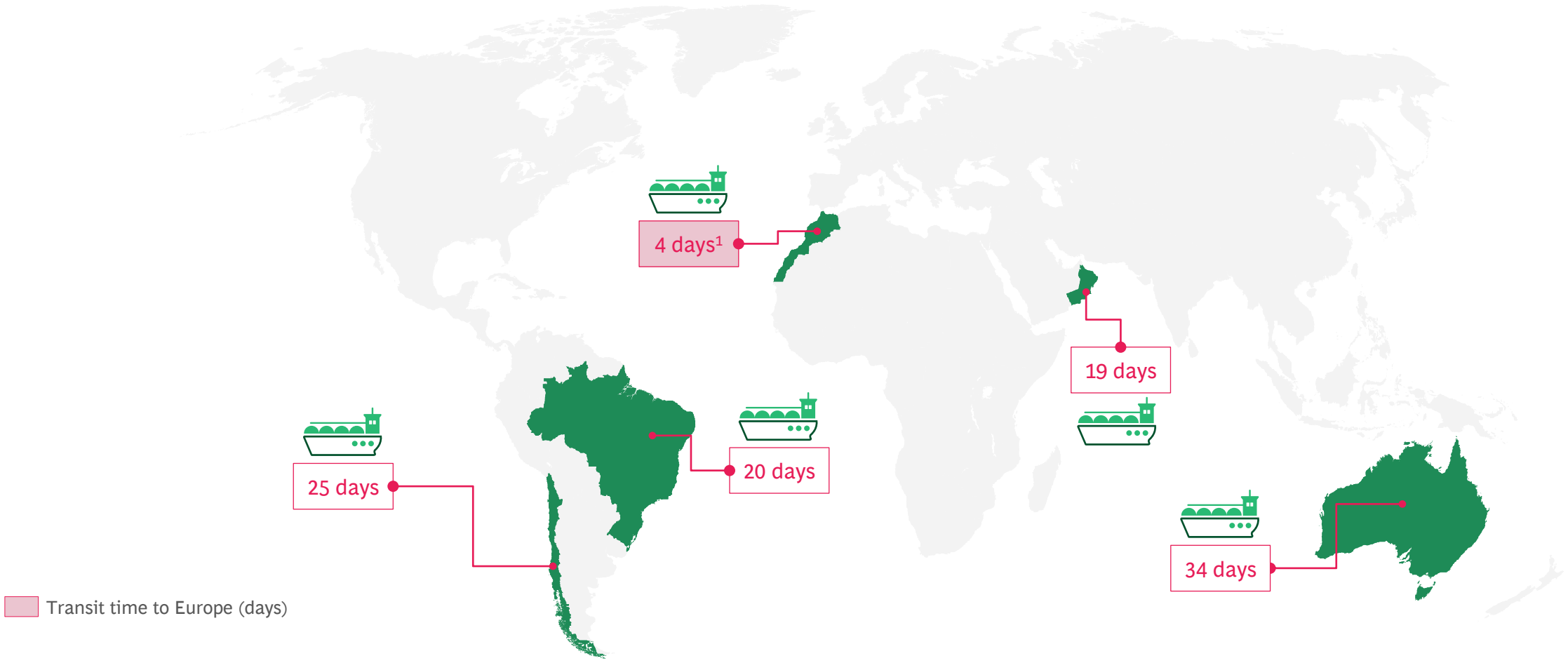
REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition*

In May 2022, the European Commission published the REPowerEU Plan – EU's strategy to eliminate energy imports from Russia by 2030.

This plan includes a target of 10Mt of domestic Renewable H_2 production and 10Mt of imports by 2030.

1. Europe considered as the cost of Netherlands, South America costs considered as the average of costs in Brazil and Chile, Africa costs considered as the average cost between Morocco and South Africa, Middle East considered as the cost of UAE
Source: BCG H_2 cost model, BCG Green H_2 demand model, BCG analysis

Green H_2 requirements | BR has faster access to Europe vs. other H_2 exporters



1. There is the possibility to transport green hydrogen from North Africa to Europe via pipelines (new pipelines or repurposing the natural gas pipelines)
Note: Considers an average speed of 13 knots
Source: SeaRates Transit Time Calculator

Green H_2 requirements | BR has access to key inputs to make Green H_2 at scale

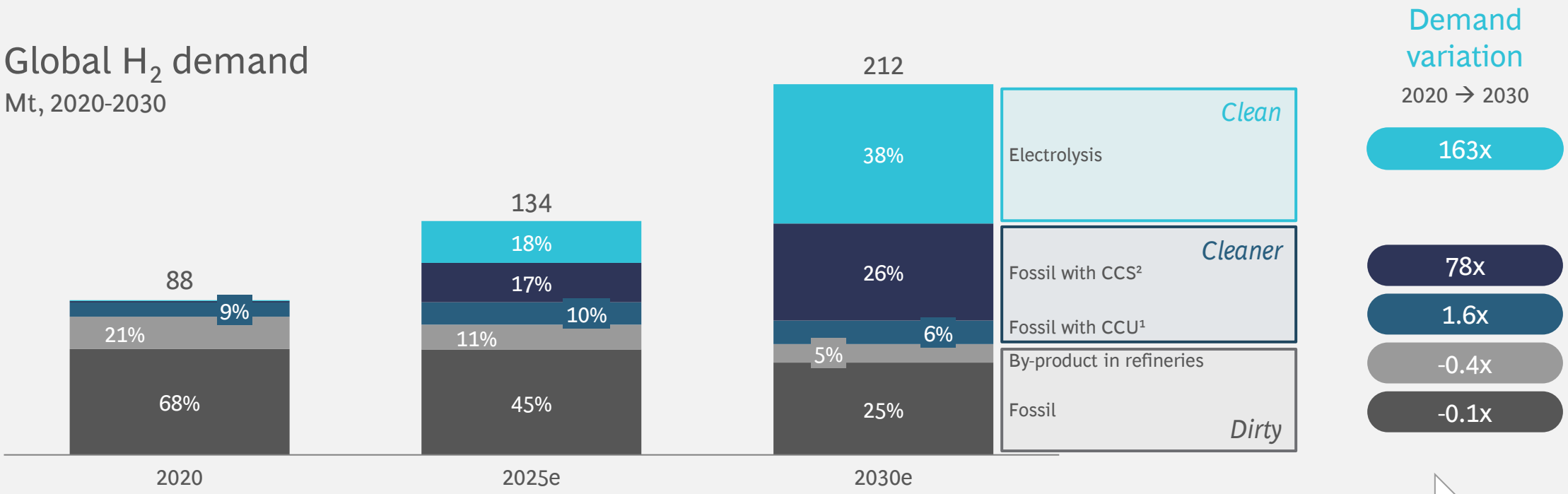
Non-exhaustive

Key factors	% of global renewable fresh water	Renewable power capacity today[1]	Renewable power potential in 2050
	~15.0%	~6mn TJ	~360mn TJ
	~2.0%	0.5mn TJ	~25mn TJ
	~1.0%	0.4mn TJ	~1500mn TJ
	~0.1%	0.1mn TJ	~75mn TJ
	~0.1%	0.0mn TJ	~15mn TJ

Better than peers

1. 2019 data
Note: Potential for 2050 per country was calculated as continent potential (Statista) multiplied by share of country area in the continent
Source: Index Mundi, Worldbank, Irena (2019), Statista, BCG analysis

… which is expected to see global demand rising ~163x due to increase in applications and in market pressure



Increase in market pressure (e.g., from regulators, investors and consumers)

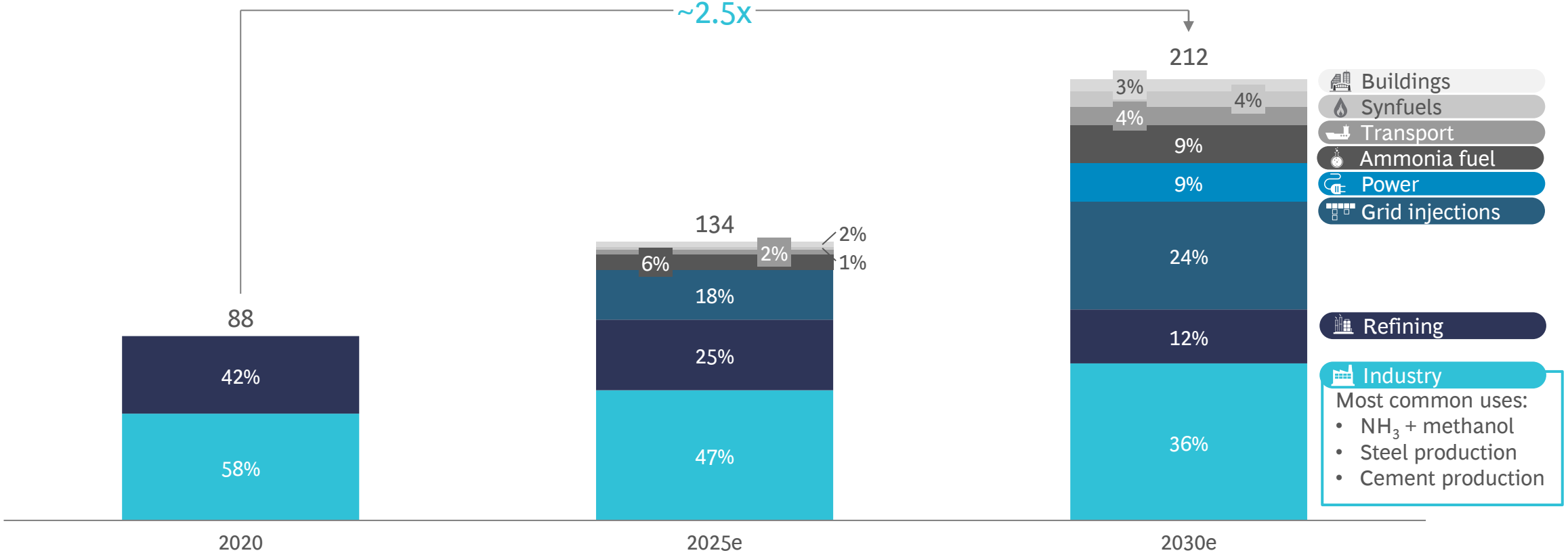
Increase in H_2 application scope (e.g., from steel/cement/refining to shipping/aviation/agriculture/others)

1. Carbon Capture and Utilization; 2. Carbon Capture and Storage
Source: Reuters (2020), REPowerEU, IRENA, IEA Agency Hydrogen Report (2021), Coherent Market Insights Report (2019), BCG analysis

Transition to Green H_2 | Hydrogen is required in several sectors and activities, w/ larger scope & demand expected in the next years

Global H_2 demand by activity

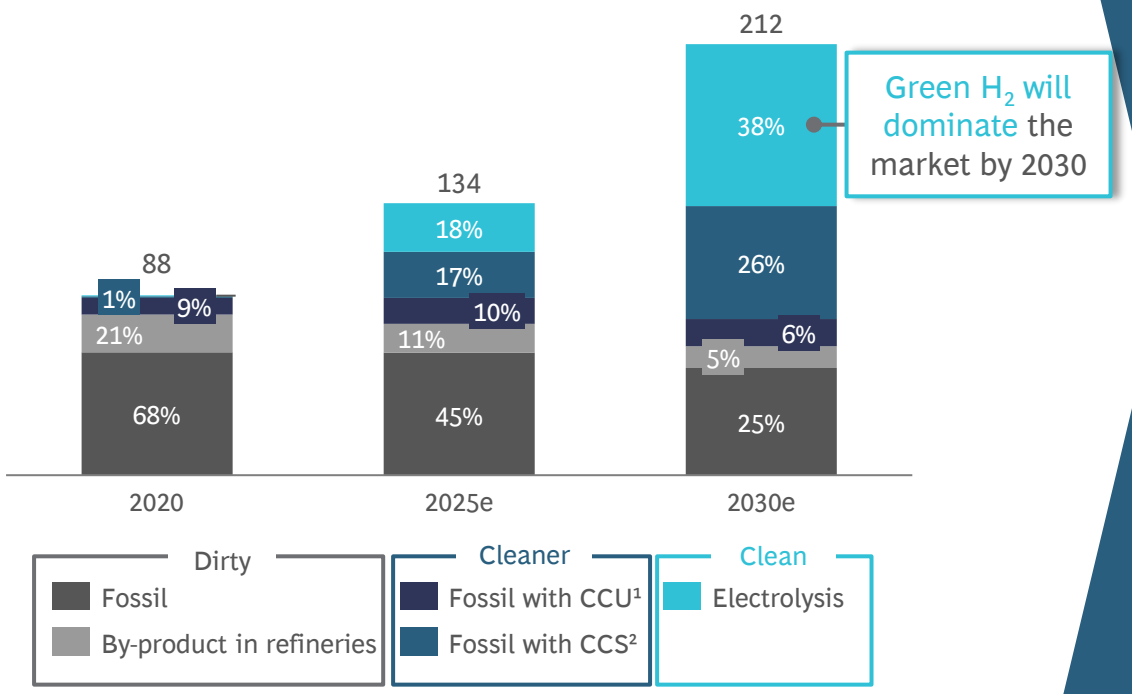
Mt



Source: IEA Agency Hydrogen Report (2021); BCG analysis

Transition to Green H_2 | World is transitioning away from fossil H_2 into greener solutions, due to pressure from regulators & investors

Emission-free H_2 expected to grow from ~1% to ~40% of global demand during the current decade…



… mainly driven by increasing pressure from regulators, investors, consumers and others

EXAMPLES

Regulators

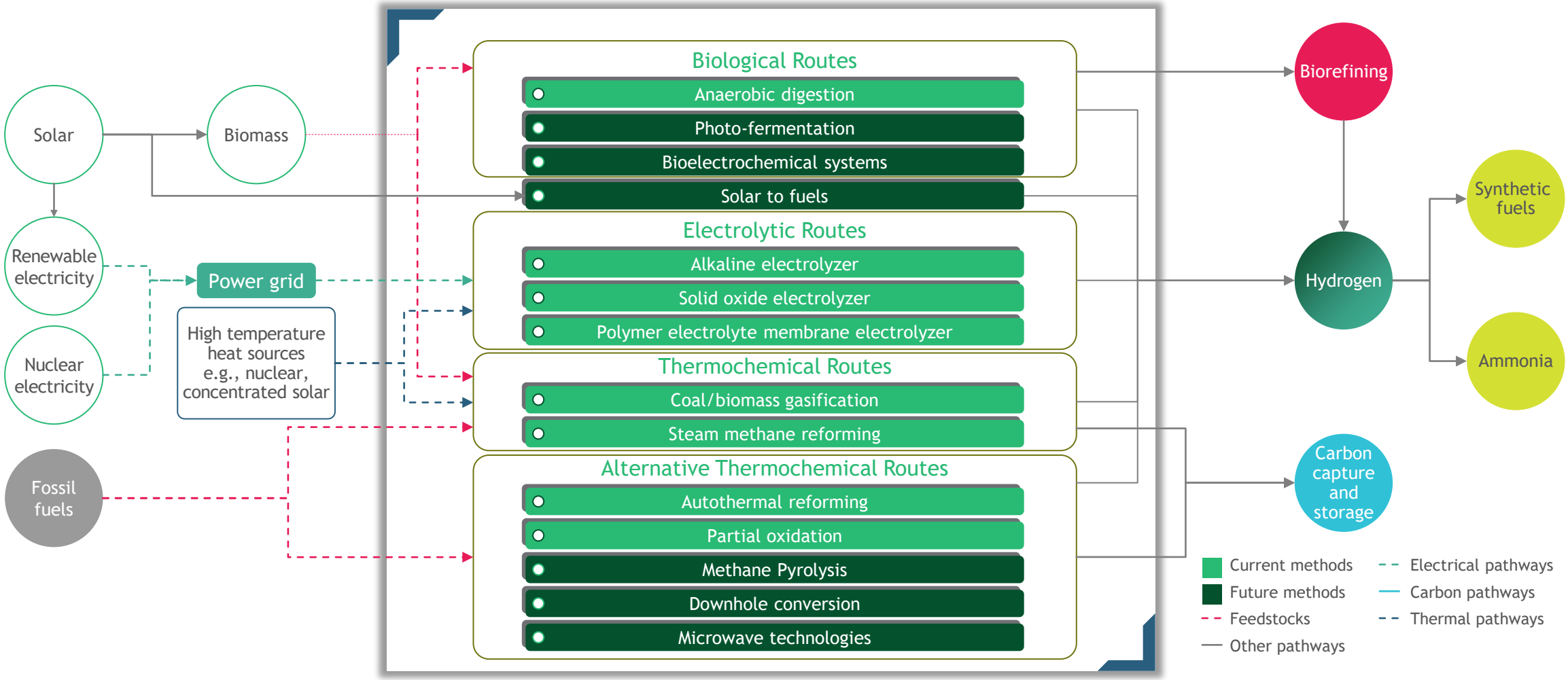
Several countries have already established and regulated carbon credit markets, which will pressure all industries & sectors to look for renewable solutions and energy sources

Investors

Net-Zero Asset Owner Alliance, a group of 30 of the world's largest asset managers (US$5T AUM³) committed to reducing their portfolio emissions by 30% until 2025 – this should affect most industries and boost use of greener solutions, such as Green H_2

1. Carbon Capture and Utilization; 2. Carbon Capture and Storage; 3. Assets under management; 4. According to Coherent Market Insights Report
Source: Reuters (2020), REPowerEU, IRENA, IEA Agency Hydrogen Report (2021), Coherent Market Insights Report (2019), BCG analysis

Transition to Green H_2 | Hydrogen is obtained from multiple clean energy sources

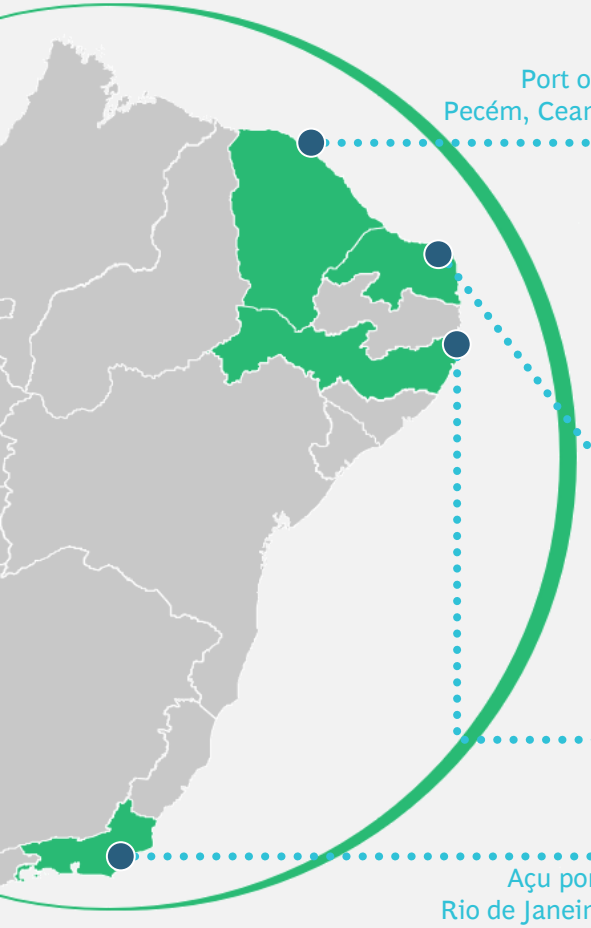


Source: The Royal Society; BCG analysis

Green H_2 already has promising investments in Brazil…

Global investors show high interest in new Green H_2 projects in different regions of Brazil

Non exhaustive



Port of Pecém, Ceará

Fortescue future
US$6 billion for a plant to operate from 2025

Transhydrogen Alliance
US$2 billion to produce 500,000 t/year

Linde
Memorandum signed for green hydrogen plant

EDP
Investment of US$7.5 million in a solar and green hydrogen plant pilot project. Operation planned for December 2022. First plant in Brazil. Note: Memorandum with Ceará government not signed

Enegix energy
US$5.4 billion invested in combined solar and wind energy to produce 600,000 t/year of green hydrogen. Base One will be the largest green hydrogen plant in the world

Qair Brazil
US$6.95 billion investment in offshore wind and green hydrogen plant, with production of 296,000 t/year

White Martins
Memorandum signed, no further information

Neoenergia/ Iberdrola
Memorandum to analyze the use of green hydrogen in public transport

Engie
Memorandum signed. Aimed at exports, but assessing use in several areas

H_2hellium
Memorandum signed to act in project development

Eneva, Differential, Hytron
Memorandum signed, no further information

MingYang
Protocol with UFC aimed at exchange and offshore wind project

Rio Grande do Norte

Enterprize Energy
Memorandum signed for offshore wind and green hydrogen plant with ammonia production

International Renewable energies
US$3.2 billion in offshore wind solar and green hydrogen plant

Neoenergia/ Iberdrola
Memorandum with intention to produce green hydrogen, no details disclosed

Port of Suape, Pernambuco

Qair Brazil
US$3.8 billion in H_2 plant

Neoenergia/ Iberdrola
Memorandum signed for the pilot of a H_2 plant, no details

Açu port Rio de Janeiro

Fortescue future
H_2 plant for production of 250,000 t/year of ammonia

Neoenergia
MOU to analyze potential for green hydrogen using offshore wind in the south of Brazil (State of RS)

!

… but Green H_2 still needs some years to fully mature

Biomass is fully mature and can play a key role in the transition phase

Source: Press release, BCG LCOH model

While Green H_2 is still maturing as a viable technology, Biomass is ready to accelerate world's transition to NZ

Key biomass sources	Market size: Volume (EJ, 2018)	Current Applications (Non-exhaustive): Biofuels	E-fuels[3]	Biogas/Biomethane	Power / heat
Bio-sourced waste					
Lipid feedstock Includes oil from palm fruits, seeds, oil waste…	53	●	○	○	○
Animal waste Includes dairy shed effluent and manure, poultry litter…		○	○	◔	◔
Forest and wood residue[4] Includes non-merchantable wood from forests, logging…		●	◔	◔	●
Agricultural waste Includes crop residues, weeds, leaf litter, sawdust…		●	◔	●	◔
Municipality waste					
SRF[1]/RDF[2] Sourced from biodegradable, recyclable and other solid waste	1.4	●	●	◔	●
Organic MSW: Includes kitchen, garden and other organic waste		●	◑	●	●
Industrial waste					
Organic industrial waste: Includes papermill sludge, meat processing, brewery wastes…	1.2	◑	◑	◔	◔
			Transport		Energy

● Most suitable option

1. Solid recovered fuel; 2. Refuse Derived Fuel; 3. Fuels produced from chemical reactions with CO_2 and H_2, powered by renewable sources 4. Use of wood my be considered sustainable if emissions are controlled and not predatory. Note: Volume estimated as the domestic supply of biomass globally. Source: World Bioenergy Organization, IEA Bioenergy, National Collaborating Center for Environmental Health, E-fuel Alliance, Y. Liu (2014), Rutz et al. (2007), BCG analysis

Biomass | Sources are already used today for transport, power and heating

Non-exhaustive

Best suited for…

Key biomass sources	Biofuels	E-fuels	Biogas	Power / heat	Comments
Lipid feedstock	●	○	○	○	Most competitive biofuel production pathway, only needs hydrogenation
Animal waste	○	○	◕	◔	Very atomized residue, high pretreatment & transportation costs; legal obligation for disposal
Forest and wood residue	●	◕	◔	●	High availability, high calorific value (~20GJ/t), and easy to transport
Agricultural waste	●	◕	●	◕	Currently often disposed; easy but expensive to transport
SRF[1]/RDF[2]	●	●	◔	●	High calorific value and concentrated volumes; low transportation costs
Organic MSW	●	◑	●	●	Cheap product but needs pre-treatment; concentrated volumes
Organic industrial waste	◑	◑	◔	◔	Concentrated volumes, but requires specific agreements with generating companies

Transport | Power & Heat

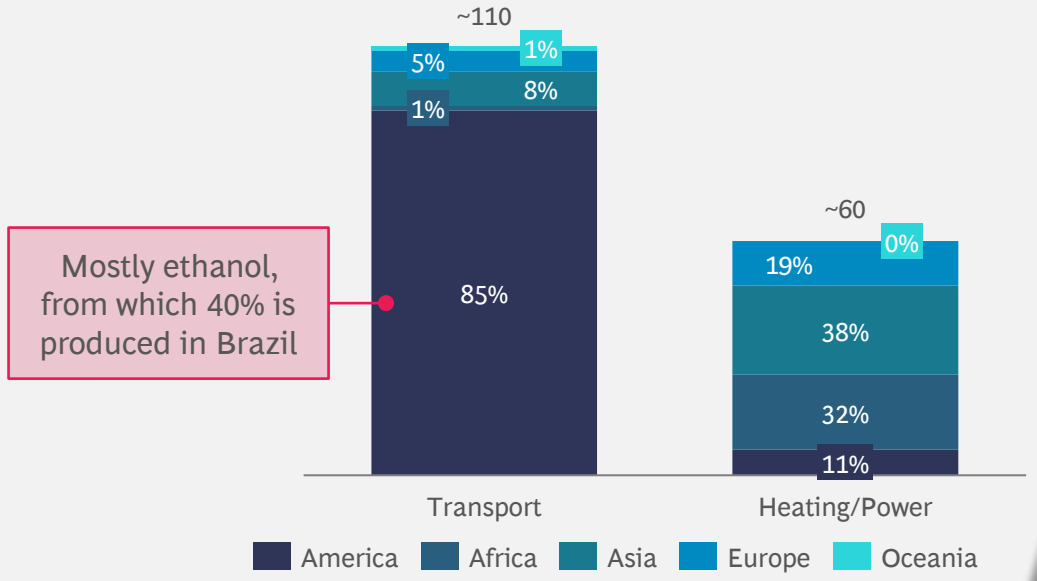
● Most suitable option

1. Solid recovered fuel; 2. Refuse Derived Fuel
Source: BCG analysis

BR is already a global biomass protagonist, especially in biofuels, with room to continue growing in coming years

Brazil is a global Biomass protagonist, especially due to production of biofuels for Transport...

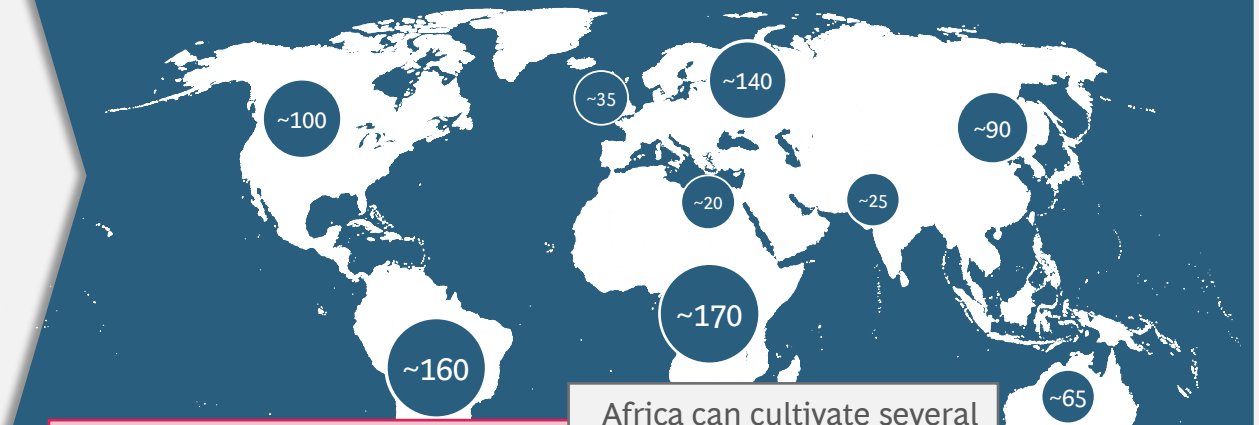
Revenues[1] by application and location (US$ Bn, 2020)



Mostly ethanol, from which 40% is produced in Brazil

... and should increasingly become relevant due to its large biofuels production potential

Forecasted biofuels capacity[2] for 2050 (EJ)



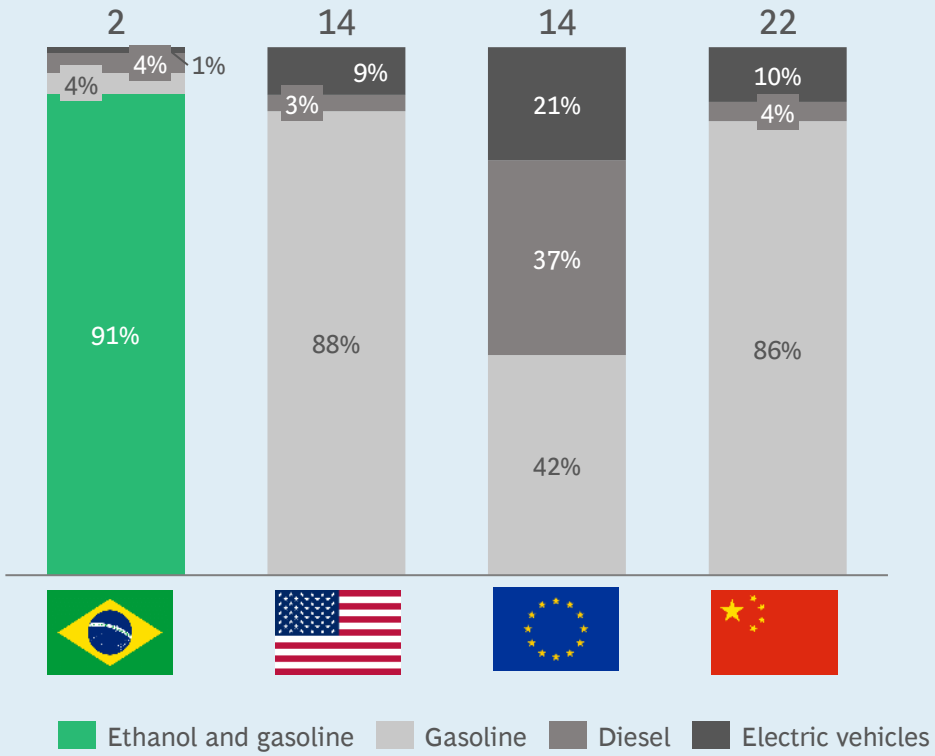
LATAM expected to hold 2nd largest potential by 2050, with Brazil representing >85%[3] of it

Africa can cultivate several types of bioenergy crops, but must tackle current issues in productivity

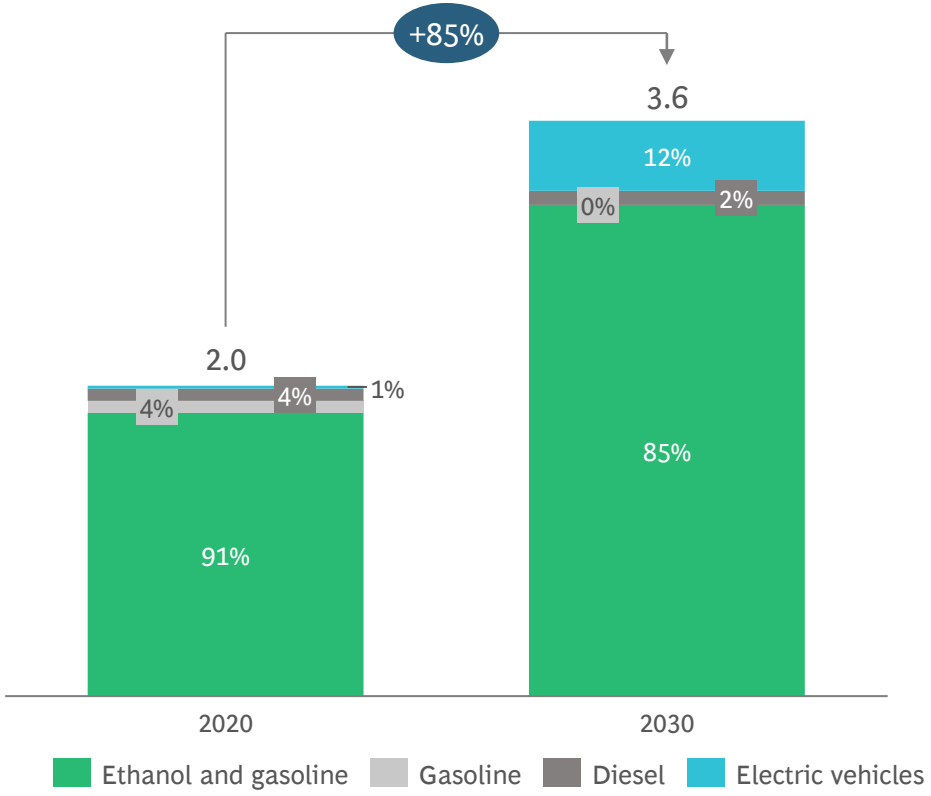
1. Based on ethanol market revenues and biomass global power market
2. Estimated based on bioenergy crops production potential; 3. Assumes current ethanol production market share will be maintained until 2050.
Note: Market shares by revenue estimated based on ethanol production market share and domestic supply of heating and power biomass sources, in EJ.
Source: Smeets & al. (2007), Naik & al. (2010), World Bioenergy Organization, US Department of Energy (2020), BCG analysis

Biofuels | Ethanol is used at scale in BR, with expected growth in coming years despite growing relevance of EVs

Additional light vehicles fleet by type of fuel and country (mn vehicles, 2020)



Forecast of additional light vehicles fleet in Brazil by type of fuel (mn vehicles)



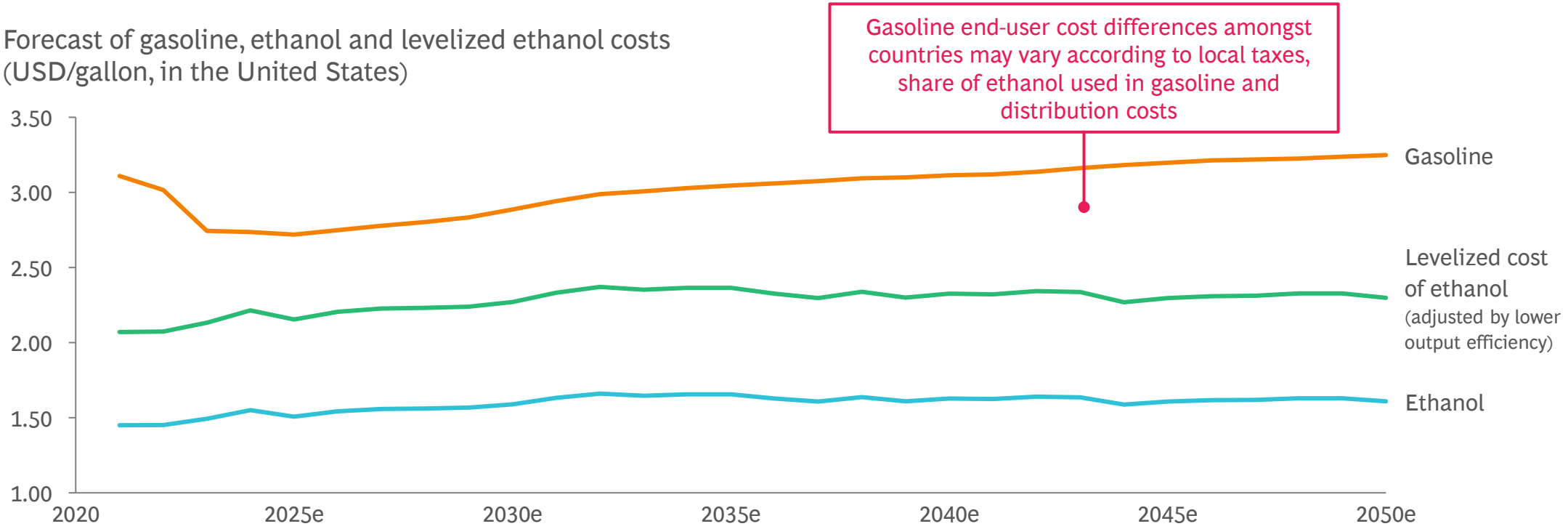
Note: Projections of Brazilian fleet consider current inertial scenario, in which new technologies such as electric vehicles are mostly used for specific situations
Source: Anfavea, Sindipeças, BCG projections (April/2021), BCG analysis

Ethanol is cost-competitive versus fossil-based fuels and is expected to remain competitive in the future

Ethanol remains cost-competitive vs gasoline besides efficiency difference

Example

Forecast of gasoline, ethanol and levelized ethanol costs (USD/gallon, in the United States)

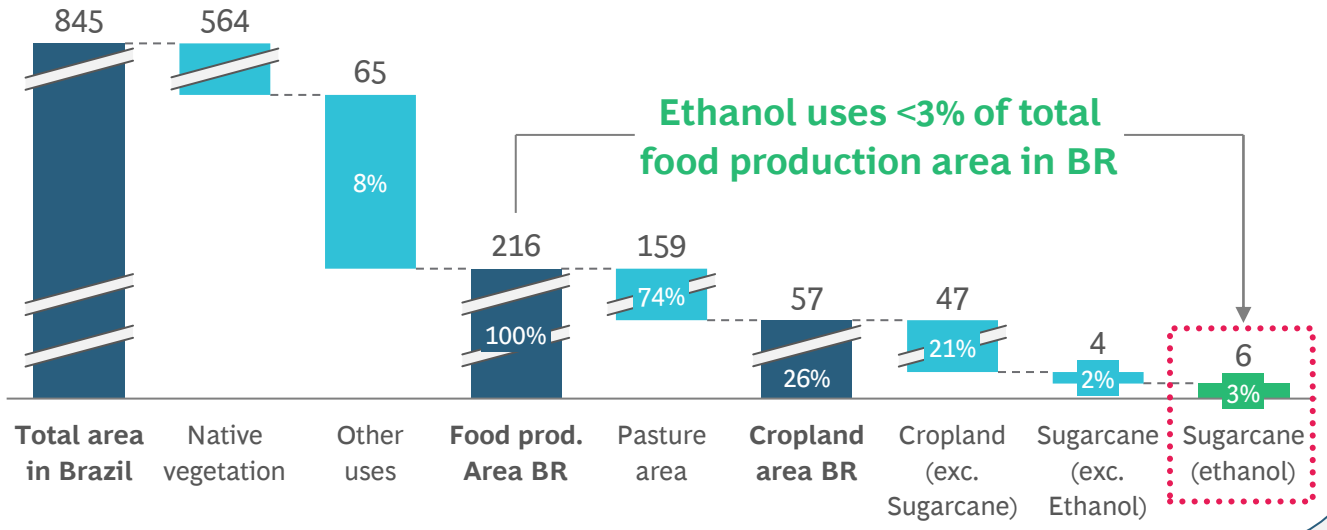


Note: Levelized cost of ethanol considers that ethanol efficiency is 70% of gasoline's
Source: Statista, Agência Brasil, Intelligent HQ, US Energy Administration Information, BCG analysis

In Brazil, Ethanol is produced using <3% of total productive land for food, while it represents ~20% of BR energy matrix

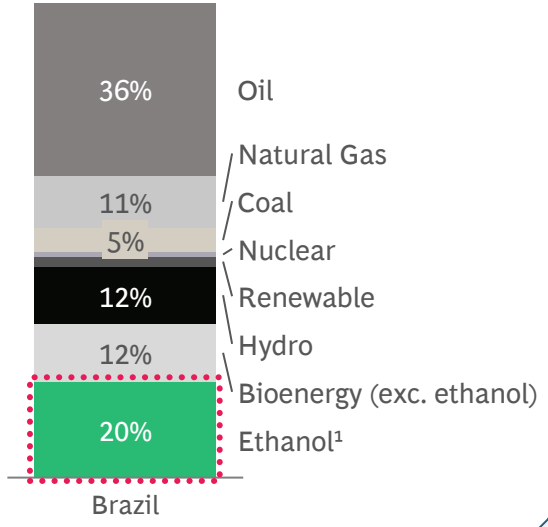
Area to produce Ethanol sums ~6mn ha (<3% of food production area)...

Total land use in Brazil
M Ha, 2019



... while Ethanol represents ~20% of BR energy matrix

Energy matrix in Brazil (%, 2019)



1. As per Balanço Energético Nacional (BEN), 2020
Source: MAPBiomas, Sugarcane Organization, Ministry o Energy (BEN), BCG analysis

Sustainable agriculture

BR could feed the planet with Sustainable Food at Scale

Food demand will grow ~30% by 2050 (from 25 to 32 Gt per year)

Brazil produces food at scale (top 1-2 in many food items, w/ abundant fresh water/Agri land)…

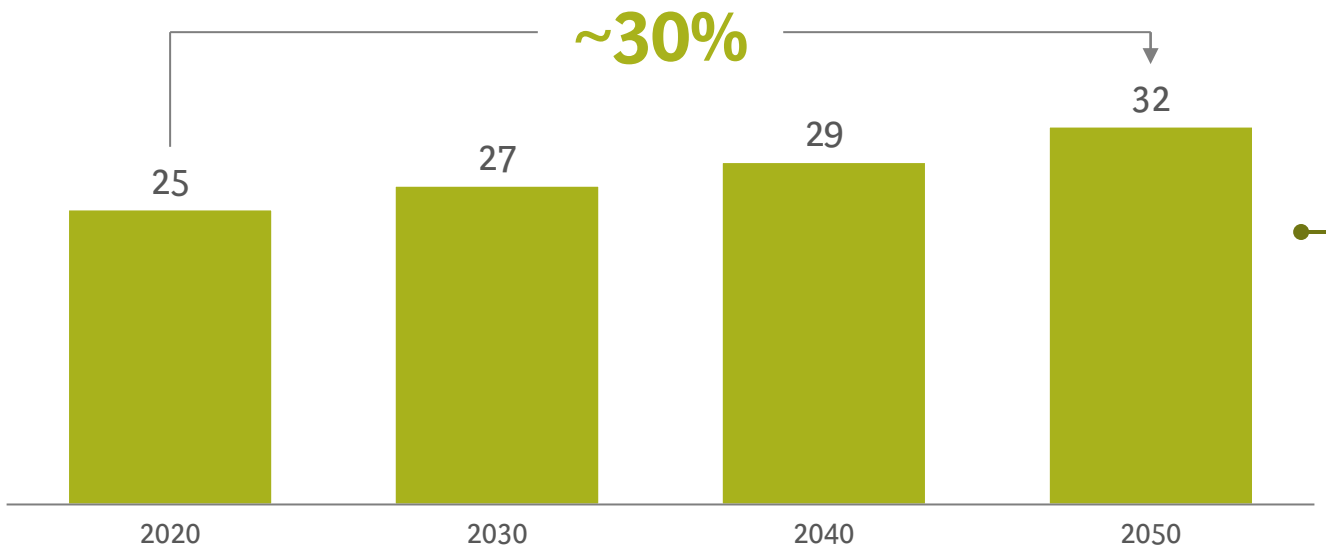
… increasingly using Regenerative Agriculture (e.g., ILPF[1] grew from ~2M to ~20M Ha between 2005 and 2020)

1. ILPF stands for Crop-Livestock-Forest Integration

Global food demand is expected to grow ~30% by 2050, creating an unprecedent challenge for Agri to achieve NZ

Demand for food is expected to grow ~30% by 2050…

Volume of agricultural commodities traded
Gt per year, Worldwide



Sustainable Agriculture at scale will be required

- **Agriculture must be reinvented** in order to feed the World with low or net-zero emissions
- **Regenerative Agriculture can help** creating sustainable food production. For instance:
  - Integrated crops, forest & animal production can achieve Net-Zero
  - No-till farming protects soil

Source: Climate TRACE, FOFAO, USDA, BCG analysis

Brazil has what it takes to grow sustainable food at scale

Three key requirements to enable Sustainable Agriculture at scale

Not exhaustive

Natural resources

~60 M Hectares of Agricultural land[1] (the 4th largest country)

15% Of global renewable fresh water (largest country)

High productivity

3x Brazil's crop yield vs world's average (gap to remain by 2050)

1.5k AgTechs in BR (+40% in 2 years) w/ focus on farming productivity

Regenerative agriculture

~20 M Hectares of Crop-Livestock-Forest Integra. in 2020 (vs.~2M in 2005)

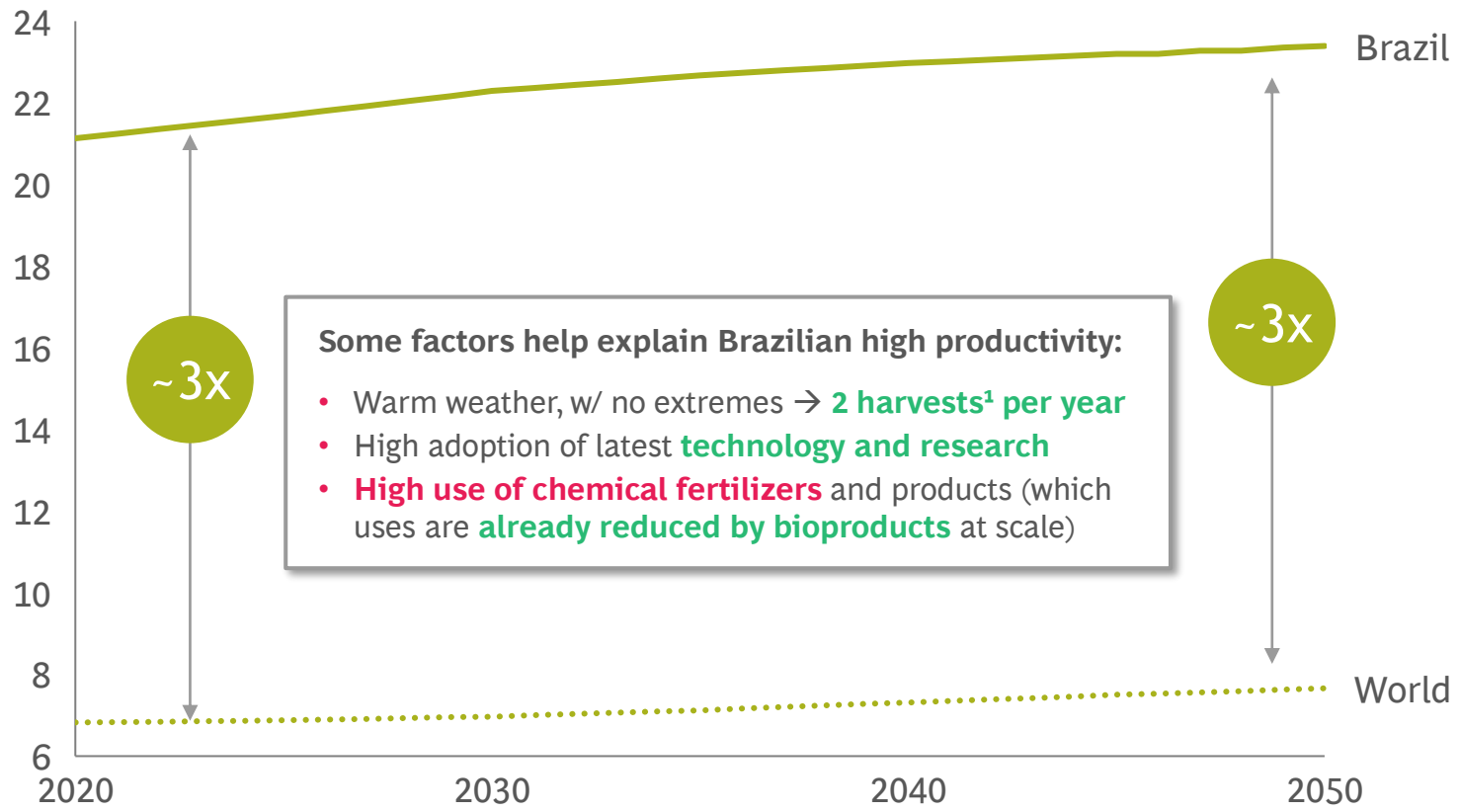
~460 USD/t 2030 Low cost of Green NH_3 enables cost-competitive supply for both domestic and export markets

Macro-factors such as favorable weather, cheap labor and civil stability enable Brazil to be a key food producer for the world

1. Land used for cultivation of crops only. It does not include land that is potentially cultivable but is not normally cultivated
Source: Index Mundi, Worldbank , Observatory of Economic Complexity, World Population Review, FOFAO, IPEA, BCG analysis

Growing productivity | Brazil is 3x more productive than world average and is expected to remain competitive in the next decades

Crop yield projections (t/ha)



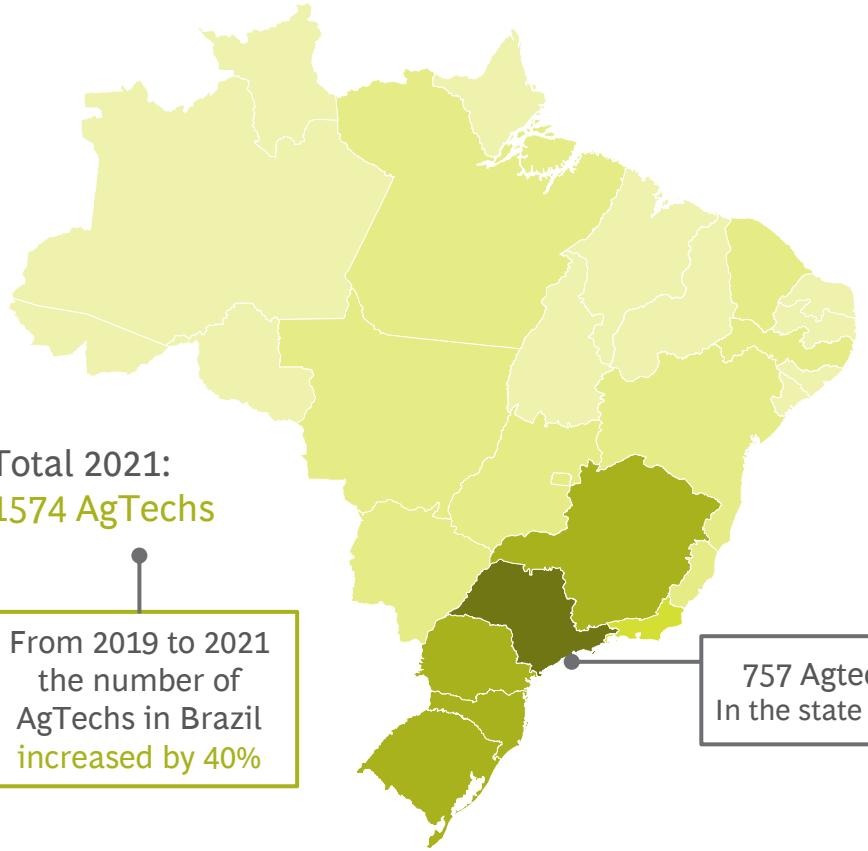
Some factors help explain Brazilian high productivity:

- Warm weather, w/ no extremes → **2 harvests[1] per year**
- High adoption of latest **technology and research**
- **High use of chemical fertilizers** and products (which uses are **already reduced by bioproducts** at scale)

1. Also known as "safrinha". Note: consider Business as Usual scenario from FOFAO Source: IPEA, FOFAO, BCG analysis

Growing productivity | AgTech hubs are growing in Brazil, with companies focused on increasing farming productivity

Heatmap of AgTechs in Brazil in 2021



Total 2021:
1574 AgTechs

From 2019 to 2021 the number of AgTechs in Brazil increased by 40%

757 Agtechs
In the state of SP

# of AgTechs	0-10	10-50	50-100	100-200	+200

Non-exhaustive

Harvest forecast applied to credit analysis

a de agro

Offers credit to farmers, using AI in risk assessment: satellite images are used to estimate historical volume and predict coming cycles

360º view of land use, compliance and financials

brain.ag
solutions in agribusiness

Big data solutions to build agrobusiness overview: credit assessment, social, legal and environment compliance, soil use, productivity…

Water use and climate forecasting

agrymet

Provides agribusiness clients information about agrometeorology to support decision making in resource management

Soil data & micronutrients info to make better decisions

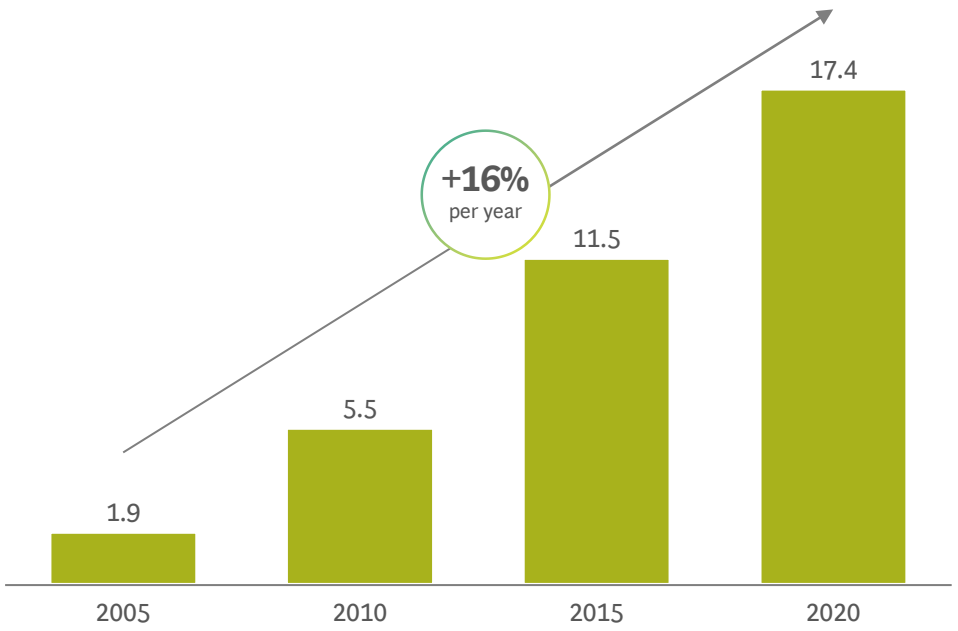
BIOME4ALL
AGRICULTURE

Uses genetic and environmental data to support sustainable decisions about soil management and crops

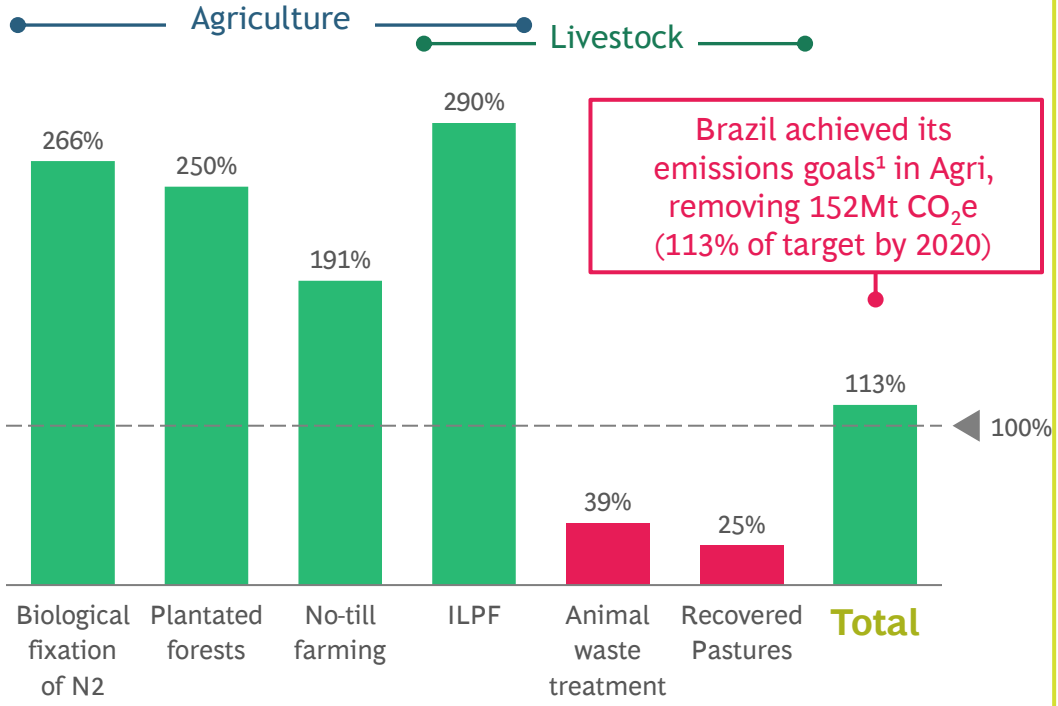
Source: Radar Agtech 2020/2021 report; BCG analysis

Regenerative Agriculture | Brazil is growing its adoption of Regenerative Agri initiatives, with tangible results in reducing emissions

Crop-Livestock-Forest Integration land use in Brazil
(M Ha)



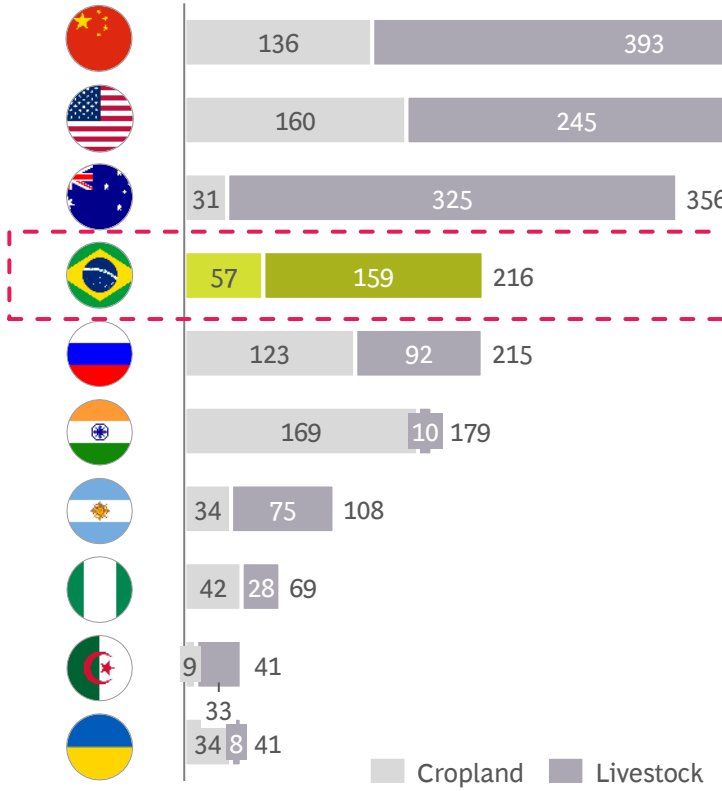
Brazil performance compared to GHG emissions target[1]
(%, 2010-2020)



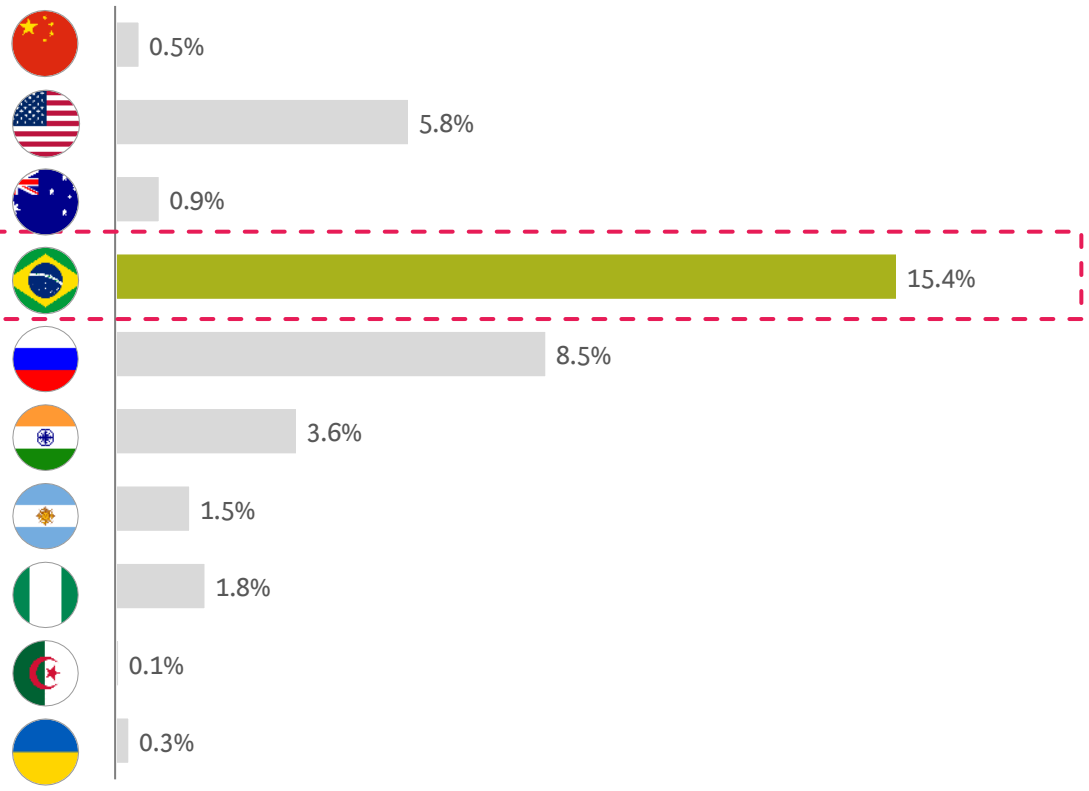
1. As per Plano ABC
Source: IPEA, BCG analysis

Food production at scale | Brazil is amongst the largest countries in arable land, holding largest share of renewable fresh water in the world

Top 10 countries in Agri land[1] ('000 Ha, 2019)



Share of renewable fresh water by country (2019)



1. Land used for cultivation of crops and animal husbandry. It does not include land that is potentially cultivable but is not normally cultivated
Source: MAPBiomas, Index Mundi, Worldbank, BCG analysis

Food production at scale | Brazil is the largest exporter of Soybeans

World exports – 10 largest exporters

2019, in US$ Billion

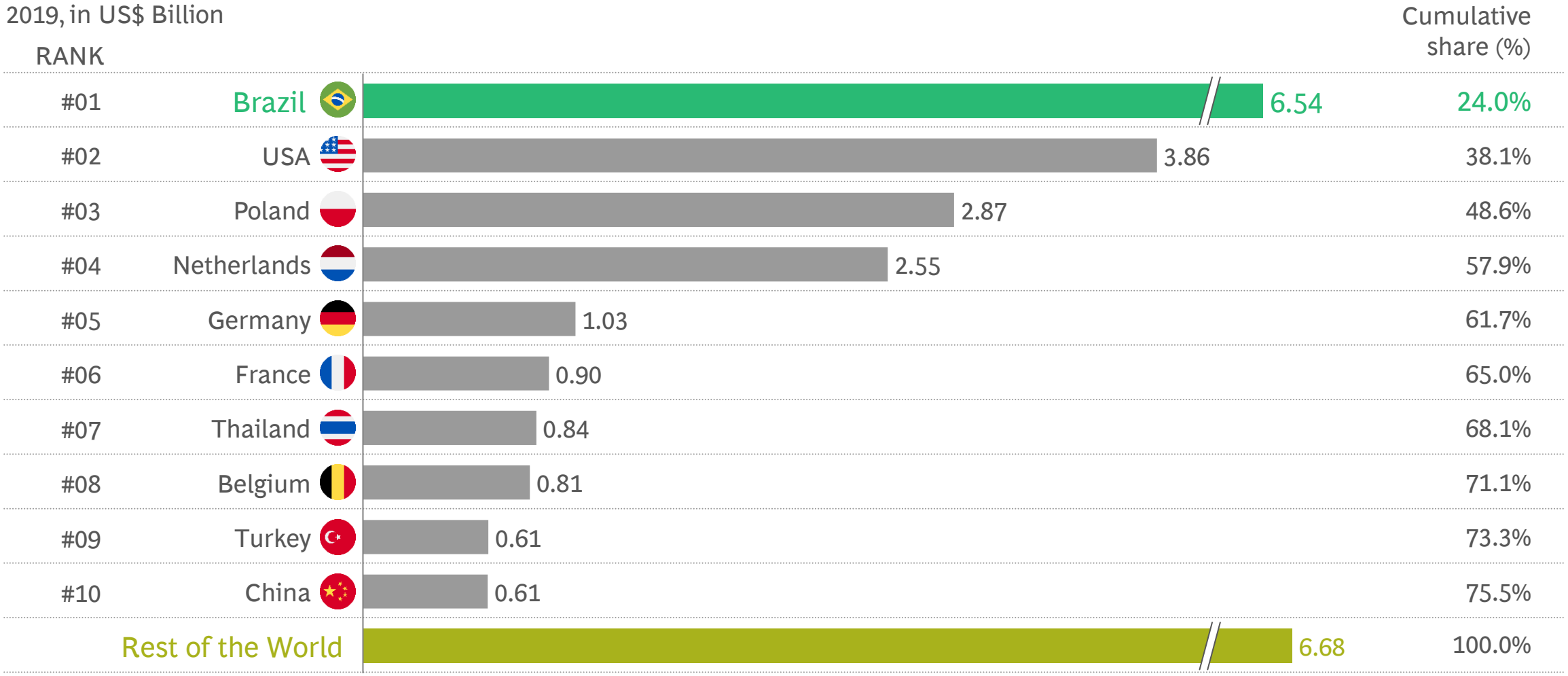
RANK			Cumulative share (%)
#01	Brazil	26.10	47.2%
#02	USA	19.20	81.9%
#03	Argentina	3.47	88.2%
#04	Paraguay	1.58	91.0%
#05	Canada	1.56	93.9%
#06	Ukraine	1.19	96.0%
#07	Uruguay	0.44	96.8%
#08	Netherlands	0.38	97.5%
#09	Russia	0.29	98.0%
#10	China	0.11	98.2%
	Rest of the World	0.98	100%

Source: Observatory of Economic Complexity; BCG analysis

Food production at scale | Brazil is the largest exporter of Poultry Meat

World exports – 10 largest exporters

2019, in US$ Billion



Source: Observatory of Economic Complexity; BCG analysis

Food production at scale | BR is the #1 exporter of Frozen Bovine Meat

World exports – 10 largest exporters

2019, in US$ Billion

RANK			Cumulative share (%)
#01	Brazil	5.68	20.1%
#02	Australia	4.81	37.1%
#03	USA	3.36	48.9%
#04	India	3.10	59.9%
#05	Argentina	2.33	68.1%
#06	N. Zealand	2.08	75.5%
#07	Uruguay	1.45	80.6%
#08	Paraguay	0.55	82.5%
#09	Ireland	0.49	84.3%
#10	UAE	0.46	85.9%
	Rest of the World	3.99	100.0%

Source: Observatory of Economic Complexity; BCG analysis

Food production at scale | Brazil is the largest exporter of Coffee

World exports – 10 largest exporters

2019, in US$ Billion

RANK			Cumulative share (%)
#01	Brazil	4.72	15.8%
#02	Vietnam	2.45	24.0%
#03	Colombia	2.38	31.9%
#04	Germany	2.38	39.9%
#05	Switzerland	2.36	47.8%
#06	Italy	1.73	53.6%
#07	France	1.18	57.5%
#08	Indonesia	0.95	60.7%
#09	Honduras	0.94	63.8%
#10	Ethiopia	0.89	66.8%
	Rest of the World	9.92	100.0%

Source: Observatory of Economic Complexity; BCG analysis

Food production at scale | Brazil is the #1 exporter of Raw Sugar, Cane

World exports – 10 largest exporters

2019, in US$ Billion

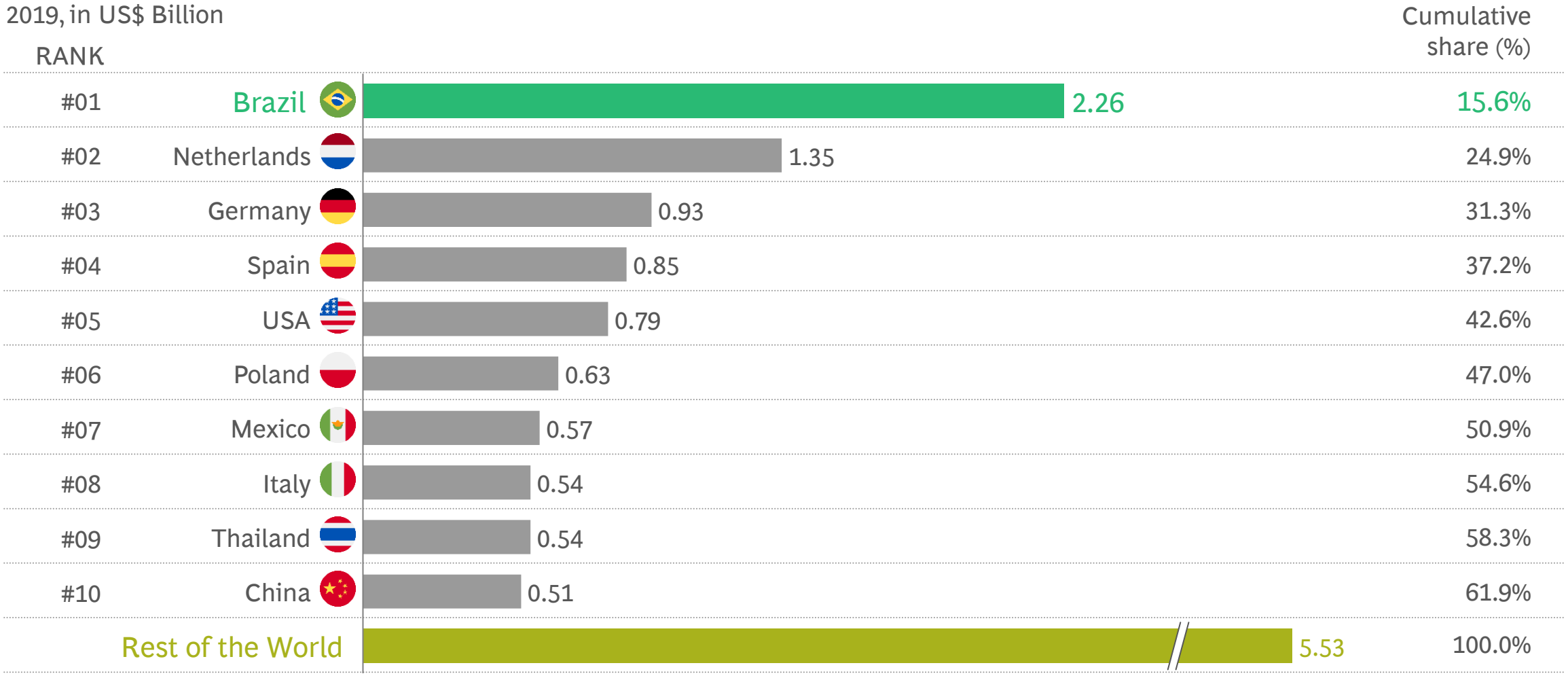
RANK			Cumulative share (%)
#01	Brazil	4.62	39.8%
#02	Thailand	1.72	54.7%
#03	Australia	0.93	62.7%
#04	Mexico	0.65	68.3%
#05	India	0.46	72.2%
#06	Eswatini	0.36	75.3%
#07	South Africa	0.34	78.3%
#08	Guatemala	0.33	81.1%
#09	Cuba	0.19	82.8%
#10	El Salvador	0.17	84.2%
	Rest of the World	1.83	100.0%

Source: Observatory of Economic Complexity; BCG analysis

Food production at scale | Brazil is the largest exporter of Fruit Juice

World exports – 10 largest exporters

2019, in US$ Billion



Source: Observatory of Economic Complexity; BCG analysis

Food production at scale | Brazil is the 2nd largest exporter of Corn

World exports – 10 largest exporters

2019, in US$ Billion

RANK			Cumulative share (%)
#01	USA	8.33	22.6%
#02	Brazil	7.39	42.6%
#03	Argentina	6.19	59.4%
#04	Ukraine	5.22	73.5%
#05	Romania	1.37	77.2%
#06	France	1.37	80.9%
#07	Hungary	0.84	83.2%
#08	Serbia	0.74	85.2%
#09	Russia	0.63	86.9%
#10	China	0.48	88.2%
	Rest of the World	4.34	100.0%

Source: Observatory of Economic Complexity; BCG analysis

Green industrial products

BR can be a global hub of low-carbon industrial goods

Thanks to its natural resources, cleaner energy matrix and biodiversity, Brazil already produces "greener" industrial items today (e.g., 11% lower emissions in cement)

Looking forward, low cost of renewables & Green H_2 can transform BR into a key supplier of low-carbon products at scale

Thanks to its cleaner energy matrix and green initiatives, Brazil already produces "greener" industrial goods today

Select examples

	Low-carbon Steel	Low-carbon Cement	Low-carbon Mining	Low-carbon Chemical
Key figures	Brazilian steel emits ~35% less than world's average (1.7 vs 2.7 t CO_2e/t steel)	**Brazil is the lowest emitting country** in the world, with 11% lower GHG emissions than world's avg.	Brazil **reduced by ~5%[1] GHG emissions by volume** in mining sector (2018-2020)	Brazil **reduced by 44% GHG emissions** in chemical industrial processes (2006-2016)
Initiatives	GERDAU Gerdau has +250k Ha of forests in MG, being the largest producer of plant-based charcoal in the world (+ high use of scrap metal)	VOTORANTIM Votorantim set a NZ goal by 2050 through replacing fossil fuels with biomass and municipality waste	VALE Vale has signed an agreement with the government of Pará to build a "green" crude iron plant in the city of Marabá	Braskem Braskem committed to becoming NZ by 2050[2] by increasing use of green plastic and clean energy, amongst other initiatives

1. Estimated based on Vale, whose estimated market share is ~55% (in revenue, 2020) 2. On scopes 1 and 2, scope 3 not included. Source: SNIC, CNI, Citi GPS, Raizen Ethanol Sustainability report, expert interview, press releases, BCG analysis

Looking forward, cheap renewables and resources can turn BR into a global supplier of low-carbon industrial products

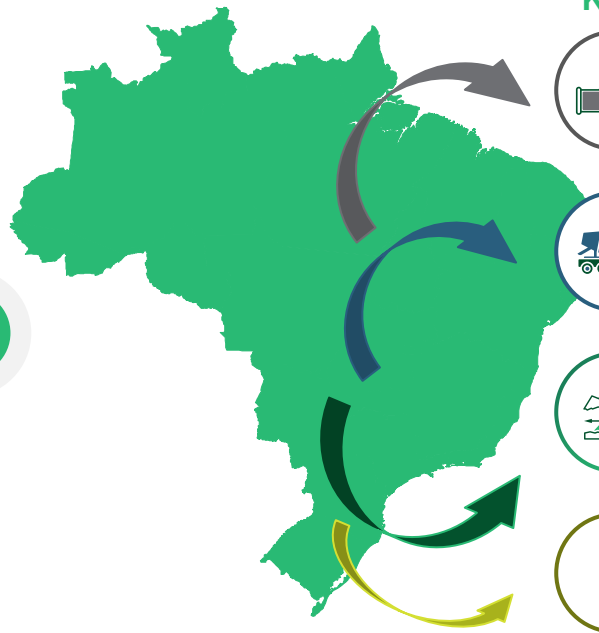
Brazil energy matrix is already cleaner than world's average…

85% Of power matrix is clean (vs. ~25% world's)

30 USD/Mwh — LCOE[1] (vs. 44 US's)

1.9 USD/t — LCOH[2] (vs. 2.7 Europe's)

… which enables Brazil to further strengthen its position as a sustainable producer in hard to abate sectors



Key potential consumers[3]

- Low-carbon Steel
- Low-carbon Cement
- Low-carbon Mining[4]
- Low-carbon Chemical

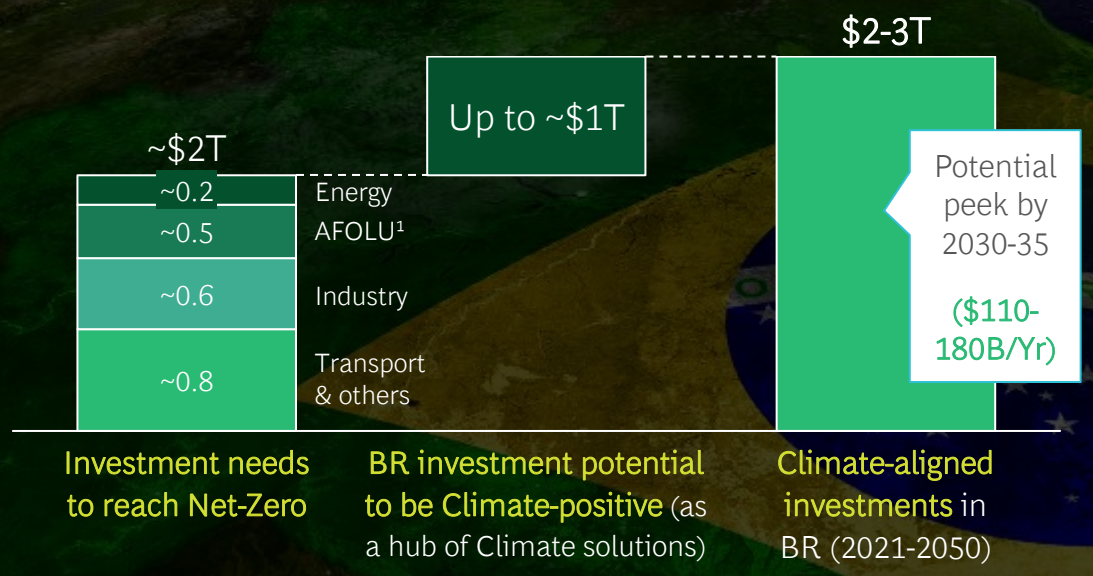
+ Final industrial products with low carbon emissions (e.g., car, airplane, machine)

1. Levelized cost of energy 2. Levelized cost of Hydrogen 3. Based on 2019 key importers 4. Considers iron ores as reference for market share
Source: Observatory of Economic Complexity; BCG analysis

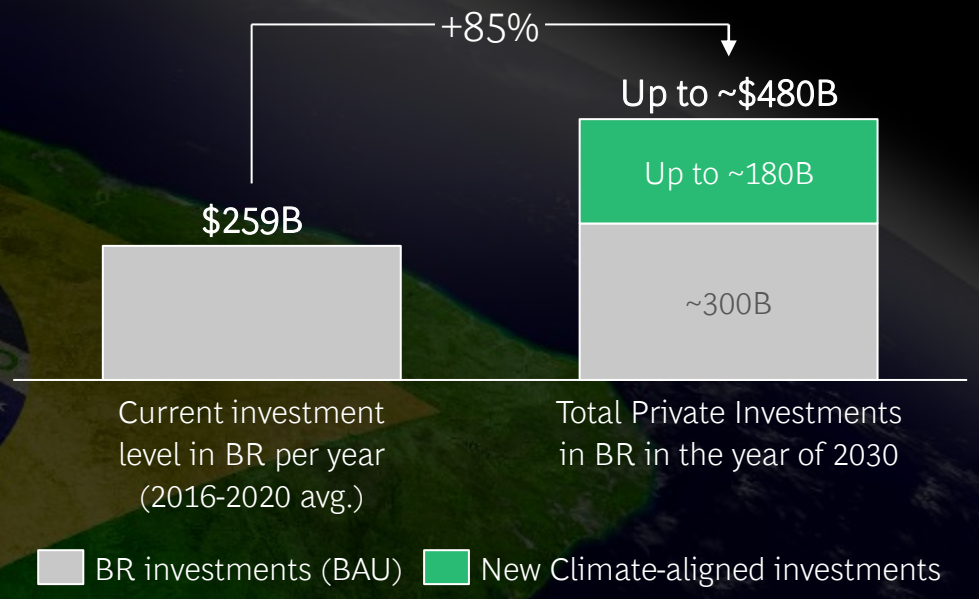
… and attract $2-3T of investments over three decades, potentially doubling BR private investment level by 2030

Preliminary

BR Climate-aligned investments expected to sum $2-3T in 2021-50, peeking by 2030-35…



… potentially doubling Brazil's annual Private Investment Level around 2030



1. Agriculture, forestry & other land use
Note: assumes Gross Fixed Capital Formation of Business-as-Usual growing in same pace as GDP, frontloaded annual distribution
Source: Oxford Economics, BCG Report – Climate Finance Markets & The Real Economy, FMI, Sebrae, BCG analysis

Investment needs | Summarized methodology for Brazil

1 Emissions baseline

Emissions baseline by sector and country were obtained from Climate Tracker dataset

×

2 Investment projections

Investments projections between 2020 and 2050 by region were obtained from the BCG Climate Report

=

3 Brazil new Climate investments

Sectoral investments were split amongst countries proportionally to their sectoral emissions.

The result was added to carbon credit and energy projected investments[1]

+

4 Brazil Business as Usual investments

Business as Usual investments were calculated as historical investment level (as % of GDP) multiplied by GDP projections

=

5 Brazil annual investment level

Annual investment level calculated as the sum of new Climate investments and Business as Usual investments

Input Analysis Output

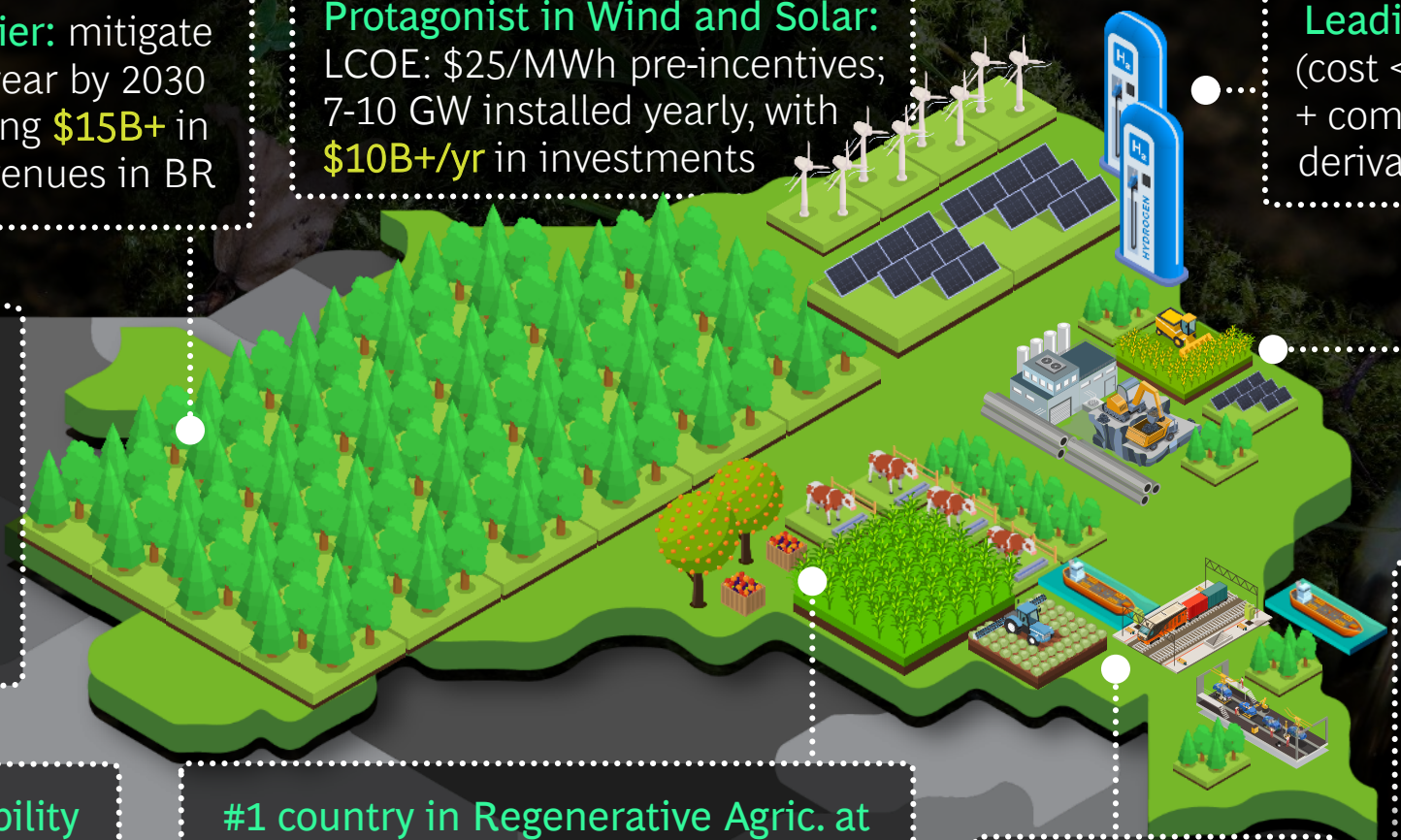
1. Investments to explore BR carbon positive potential were estimated based on two key categories mapped: Nature-based solutions and Clean Energy. Other levers, like green industrial products, exist but are expected to hold smaller potential or are partially covered by either NBS or Energy. Source: BCG analysis

Brazil 2030 Ambition | Global Hub of Climate Solutions

#1 CO_2-offset supplier: mitigate 300+ Mt CO_2e per year by 2030 through NBS, creating **$15B+** in additional yearly revenues in BR

Protagonist in Wind and Solar: LCOE: $25/MWh pre-incentives; 7-10 GW installed yearly, with **$10B+/yr** in investments

Leading Green H_2 producer (cost <$1.9/Kg pre-incentives + competitive/fast delivery of derivatives to Europe/others)



Zero illegal deforestation through command and control (tech + law enforcement) & effective fighting of natural fires

Global leader in Biomass for Energy, Transport & Industry

Worldwide Hub for low-carbon industrial products, benefiting from clean energy, competitive Green H_2, natural resources, NBS supply and use of scrap materials

Increased **Sustainability** in **wastewater treatment** coverage and **clean water supply** capacity

#1 country in Regenerative Agric. at scale (from ~20 M Ha today to 100+ M Ha of Crop-Livestock-Forest Integration or no-till farming)

Modal expansion (waterway, rail) to cut GHGs further

NOW is the time to act!

Brazilian business leaders have an unique opportunity to accelerate world's journey to NZ

Brazil Climate Summit.

Action plan to Seize BR Climate Potential

Brazil Climate Summit.

BR is currently committed to zero illegal deforestation by 2028 and to reach NZ in GHG emissions by 2050

Evolution of Brazilian commitments

	2016 (Paris Agreement)	2020 (NDC[1])	2021 (COP 26)	2022 (NDC)
2025 GOAL Gt CO_2e	1.30	1.79	1.79	1.61
2030 GOAL Gt CO_2e	1.20	1.62	1.62	1.28
Zero illegal Deforestation	2030	2030	2030	2028
Net Zero by	-	2060	2050	2050

CURRENT TARGETS

Short-term goals adjusted mainly due to a detailed revision of the 2005 baseline for the country

Targets added in the last 2 years

1. NDC stands for National Determined Contribution
Source: Brazil's NDC submission; NDC do Brasil: Avaliação da atualização submetida à UNFCCC 2022; BCG analysis

To reach Net-Zero, all BR stakeholders must be involved

MAIN FOCUS OF THIS REPORT

Governments

1. **Set net-zero ambition** (Aligned to Paris agreement)
2. **Define roadmap** (With interim targets by sector)
3. **Introduce carbon pricing** (And protect industry, low-earners)
4. **Sector regulations** (Enforcement, standards, subsidies)
5. **Engage stakeholders** (To enable "equitable" transition)

Corporations

5. **Set ambitious targets** (Aligned to Paris agreement)
6. **Reduce CO_2 intensity** (On operations and value chains)
7. **Assess climate risks** (Internal carbon price, apply TCFD[1])
8. **Innovate** (Business model, technology)
9. **Engage stakeholders** (Employees, policy-makers)

Investors

11. **Push for transparency** (Standards on emissions, ESG risks & impact measurem. frameworks)
12. **Scrutinize targets** (On operations and value chain)
13. **Support plans, actions** (Full decarbonization, green revenues)
14. **Recalibrate valuations** (Of long-tail carbon risks)
15. **Commit 'green' capital** (To scale-up zero carbon solutions)

Individuals

16. **Influence and lead** (Your organization, government, others)
17. **Make your home green** (Green power, recycle)
18. **Change mobility habits** (EVs, bike, public transport; fly less)
19. **Buy green** (Sustainable products; shared services)
20. **Have a sustainable diet** (more local, more social, compensated sources)

1. TCFD stands for Task Force on Climate-Related Financial Disclosures
Source: Grantham Institute; OECD; IPCC; IEA; IRENA; BCG analysis

Leaders are urged to engage and boost Brazil's Climate potential

1 Vision: Brazil as a Global Hub of Climate Solutions, helping the world transition to Net-Zero

2 Challenges & opportunities

	Forests	Cattle raising	Agriculture	Energy[2]	Transport	Waste	Manufacturing & construction	Metals & minerals
% of current emissions[1]	~49%	~14%	~7%	~8%	~8%	~7%	~5%	~2%
	AFOLU[3]						Industry	

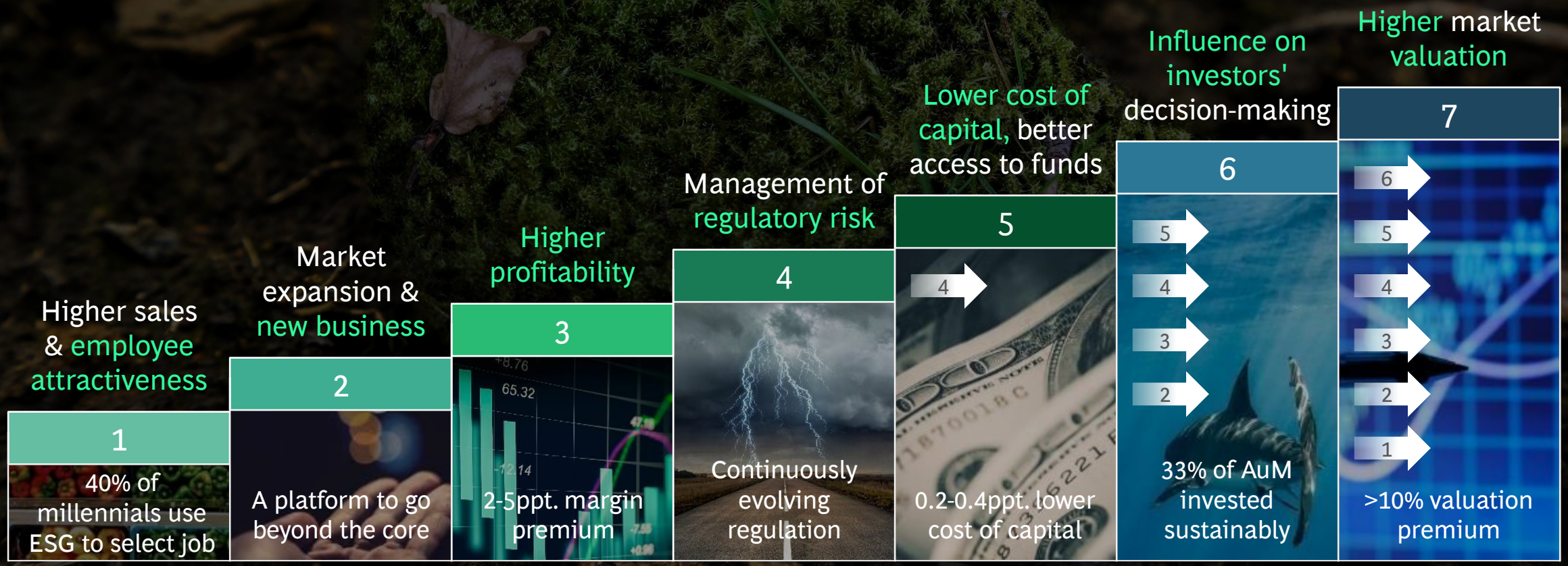
3 Key Enablers

- Access to cheap funding
- Capacitation and skilling
- Fostering of Innovation
- Policy and governance
- Infra. planning and roll-out

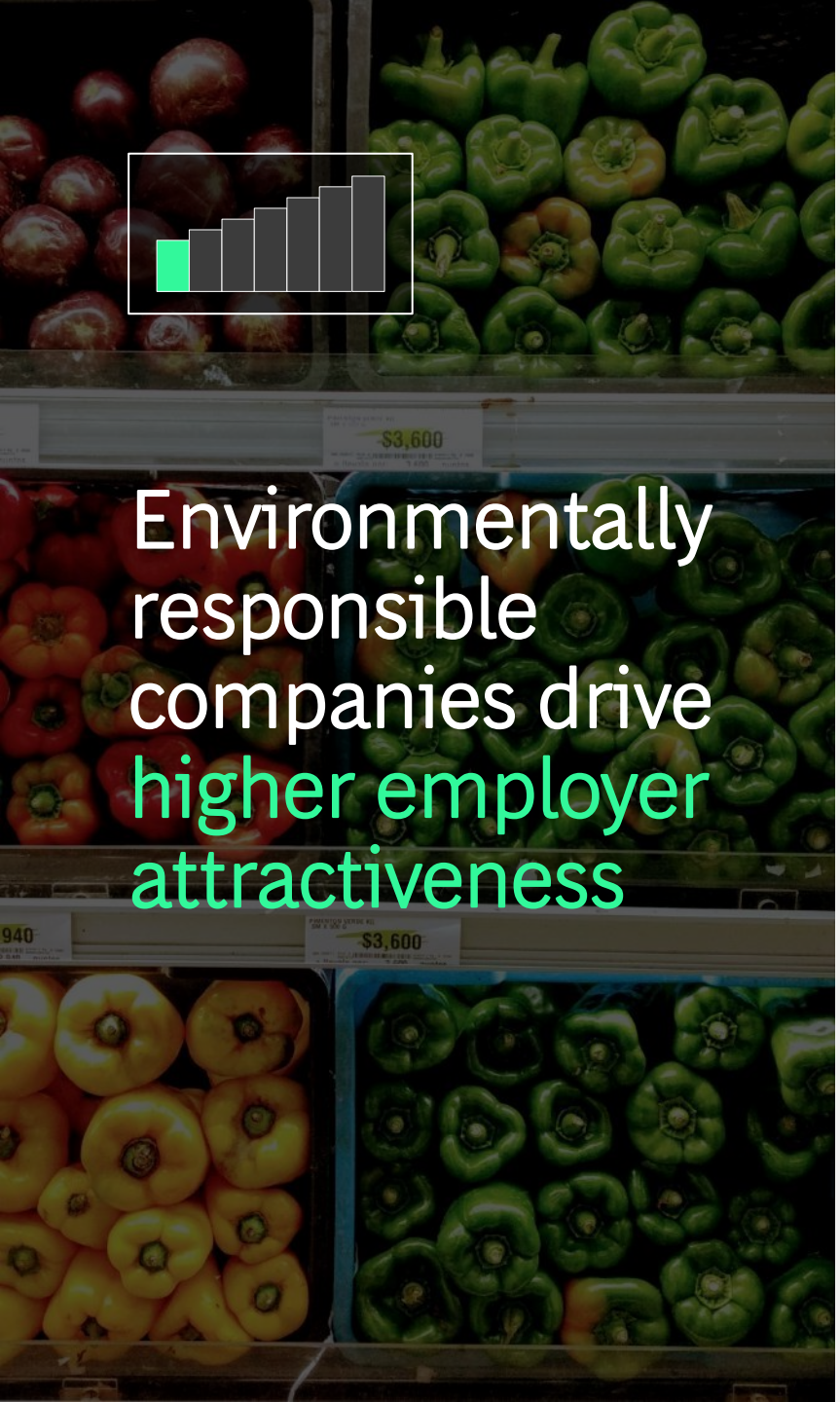
4 Stakeholder collaboration and coordination is key to all building blocks

1. As of 2019 2. Includes O&G 3. Combination of agriculture, forestry & other land use
Source: Climate TRACE; BCG analysis

Acting fast can bring strategic early-mover advantages to Brazilian companies…



Source: BCG Analysis



Environmentally responsible companies drive higher employer attractiveness

…expectations from the public have changed…

> There is one and only one social responsibility of business—to use its resources and engage in activities designed to increase its profits
>
> Milton Friedman, 1970

> The climate crisis has already been solved. We already have all the facts and solutions. All we have to do is to wake up and change.
>
> Greta Thunberg, 2018

Life Magazine 1962

Time Magazine, December 2019

…as well as those from (potential) employees

~40% of millennials said that they've chosen a job in the past because the company performed better on sustainability than the alternative

~30% of employees said that they've left a job in the past because of the company's lack of a sustainability plan

Source: World Resource Institute 2018; Accenture Chemicals Global Consumer Sustainability Survey; BCG analysis

Sustainability leads to market expansion & new business fields

~50% of CPG growth ('13-'18) in the US came from sustainability-marketed products, despite representing only 16.6% of the category in '18

Industry Examples

~4M New sales by C&A with new C2C[1] Certified apparel line in first two years[2] – best-selling products with margins on par with conventionals

69% Faster growth for Unilever's "sustainable living" brands vs rest of business, relating to 75% of Unilever's total revenue growth

>1M New sales by global shoe manufacturer with new line of sneakers made from recycled ocean plastic PET bottles

€11.5B Green revenues (~64% of total sales) were generated by Philips in 2018

1. Cradle to Cradle; 2. 2017 & 2018
Source: NYU Stern Center for Sustainable Business; C&A; Unilever; Philips; BCG analysis

Environmentally responsible actions drive higher profitability

Companies performing best in ESG metrics deliver improved economic fundamentals

Selected examples

Environment

Reducing water stress[2]

4.1

EBITDA margin premium (pp)[1]

Example from CPG industry

Social

Promoting employee safety[3]

4.6

EBITDA margin premium (pp)[1]

Example from biopharma industry

Governance

Avoiding & combating corruption[4]

2.3

Net income margin (pp)[1]

Example from banking industry

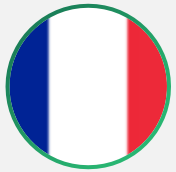
1. Average premium of top versus median ESG performers, all else equal; 2. Other environment topic examples with positive impact on EBITDA margin within same industry: minimizing product and packaging lifecycle impacts (3.1pp), limiting negative impacts to biodiversity and ecology (3.0pp), ensuring responsible environmental footprint (1.3pp); 3. Other social topic examples with positive impact on EBITDA margin within same industry: expanding access to drugs (8.2pp), conducting ethical human clinical trials (6.1pp), promoting transparent lobbying (5.1pp); 4. Other governance topic examples with positive impact on Net income margin within same industry: ensuring fair debt collection (0.5pp), ensuring fair selling practices (0.4pp), environmentally responsible sourcing (3.4pp), promoting financial inclusion (0.5pp)

Source: MSCI ESG Research LLC; OEKOM research AG; BCG analysis

Regulators are raising the bar

EU leading in non-financial disclosures with others expected to follow

- 2014/95 NFRD identifies four sustainability issues that large, public-interest companies must report
- 2016/1011 and 2019/2089 include requirements for climate transition and Paris benchmarks in financial services
- "Green Taxonomy" for sustainable investments in progress
- "Plastic waste tax" – introduced, minimum recycled targets aspired



- Article 173 requires listed companies to report on financial risks related to climate change and measures adopted to reduce them
- Carbon Regulation with increasing carbon prices

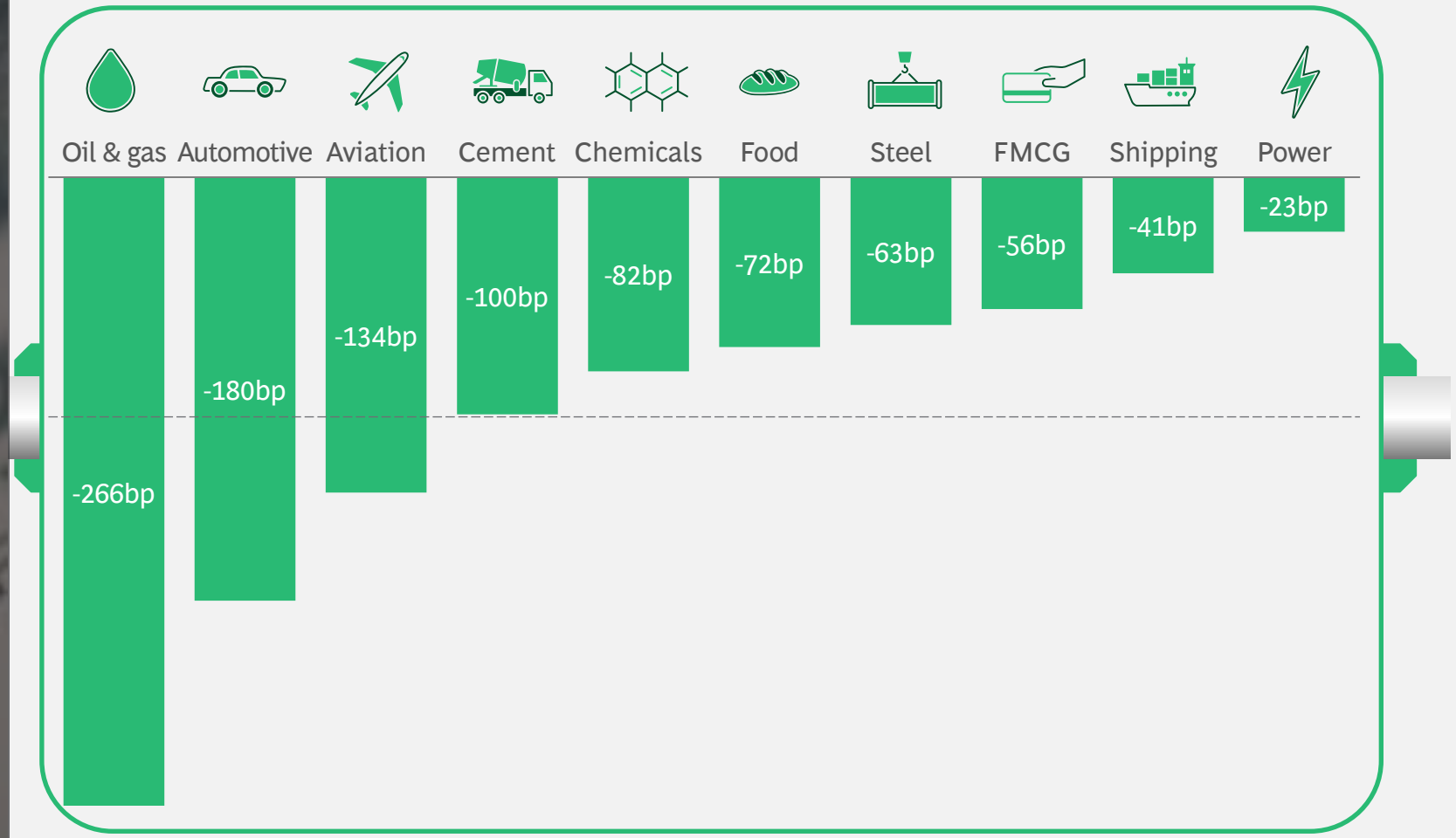
- Congress discussing SEC's role in ESG & climate disclosure for the first time in history (ESG Disclosure Simplification Act, Climate Risk Disclosure Act…)
- 27 States with e-waste regulation – e.g., Indiana, EPR unless 60%+ recycled based on weight sold
- California AB54/SB84 – packaging regulation

- Xi Jinping's calling for "green finance" and Hong Kong now requiring reporting on ESG risks and materiality methodology
- "Plastic Waste Import Ban" – regulation prohibits import from certain type of plastics packaging with low grades and high pollution

Source: BCG analysis

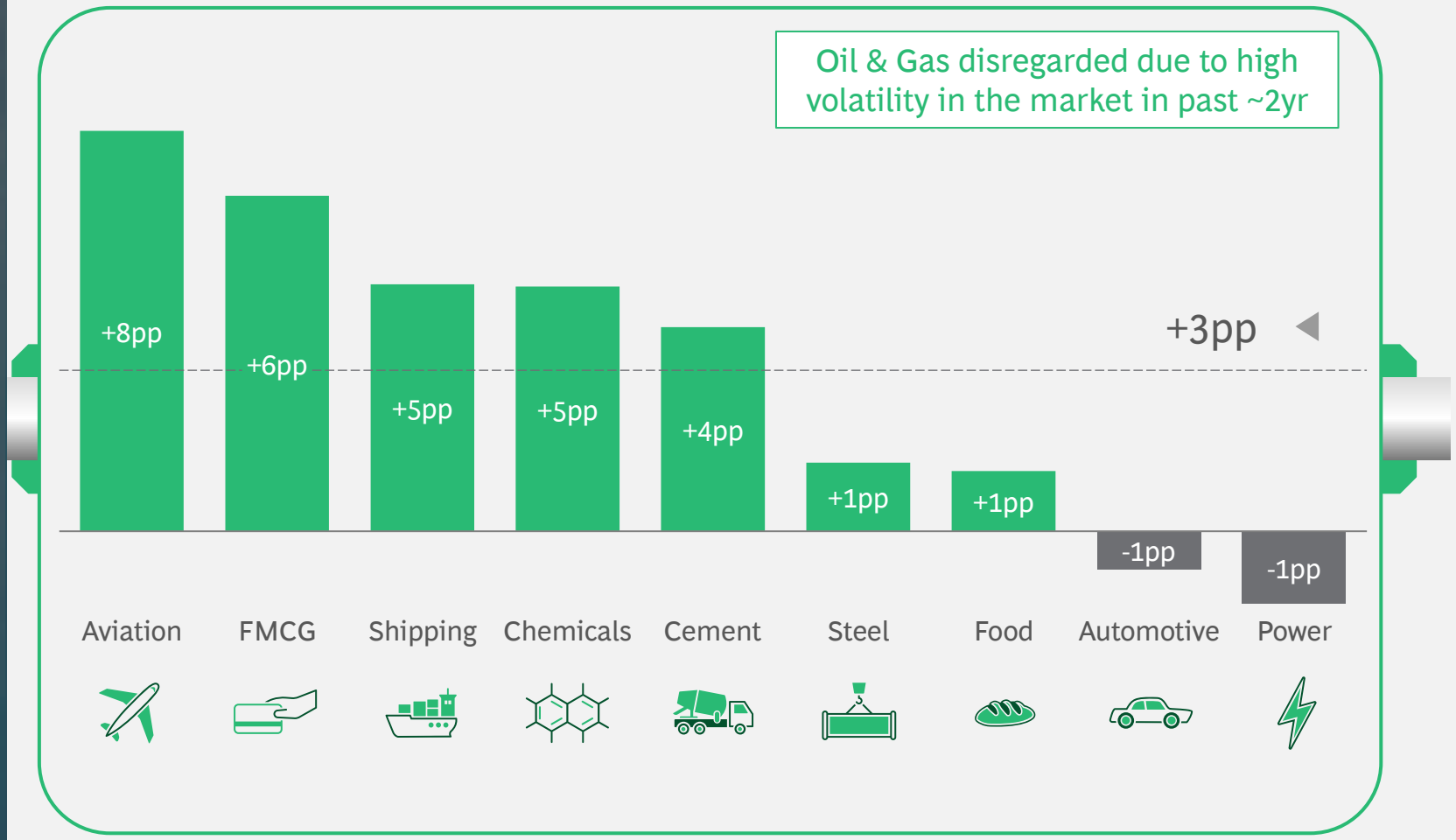
And allow companies to access cheaper capital…

Average WACC discount[1] of Western-European sustainability leaders vs. laggards



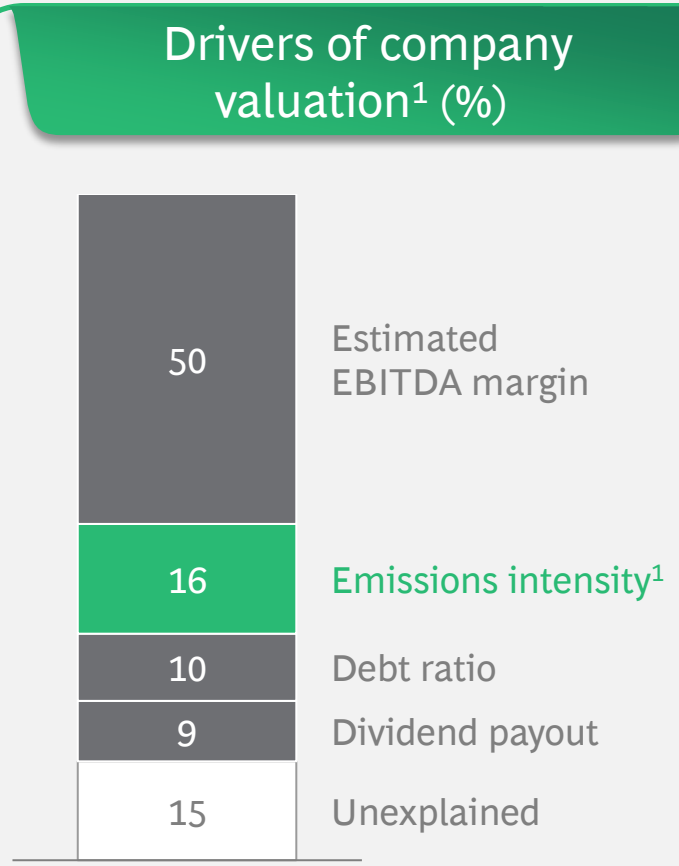
1. Simple average WACC % (leaders – laggards), outliers removed from sample per interquartile range rule
Note: Sustainability leaders (laggards) defined as top (bottom) quartile Refinitiv Environmental Pillar score; geographical scope limited to control for regional variation in WACC. Source: Refinitiv data (29/11/2021) for listed companies with >$500M market cap (>$5B for automotive due to consolidated nature of industry), BCG analysis

…and better and higher returns for shareholders influencing on investor decision-making



Source: BCG analysis

Company valuation benefits from lower emissions intensity



BCG's Value Creators Report 2021 found emissions intensity as second largest driver of company valuation

Less carbon-intensive companies saw higher valuations than their more carbon-intensive peers, all else being equal

1. Considering nonfinancial variables in financial regression analysis; 2. Scope 1 and 2 emissions per dollar of revenue
Source: BCG's Value Creators Report 2021: Value Creation in a Decarbonizing Economy; S&P Capital IQ; BCG ValueScience Center

… and concrete benefits to the BR economy as a whole

A net increase of
more than **2** million jobs

A total GPD gain of
US$ **535** Billion
(R$ 2.8 trillion)

Restoration of
12 million hectares
Or more of degraded pasturelands

US$ **3.7** Billion
(R$ 19 billion)
In additional Agri production

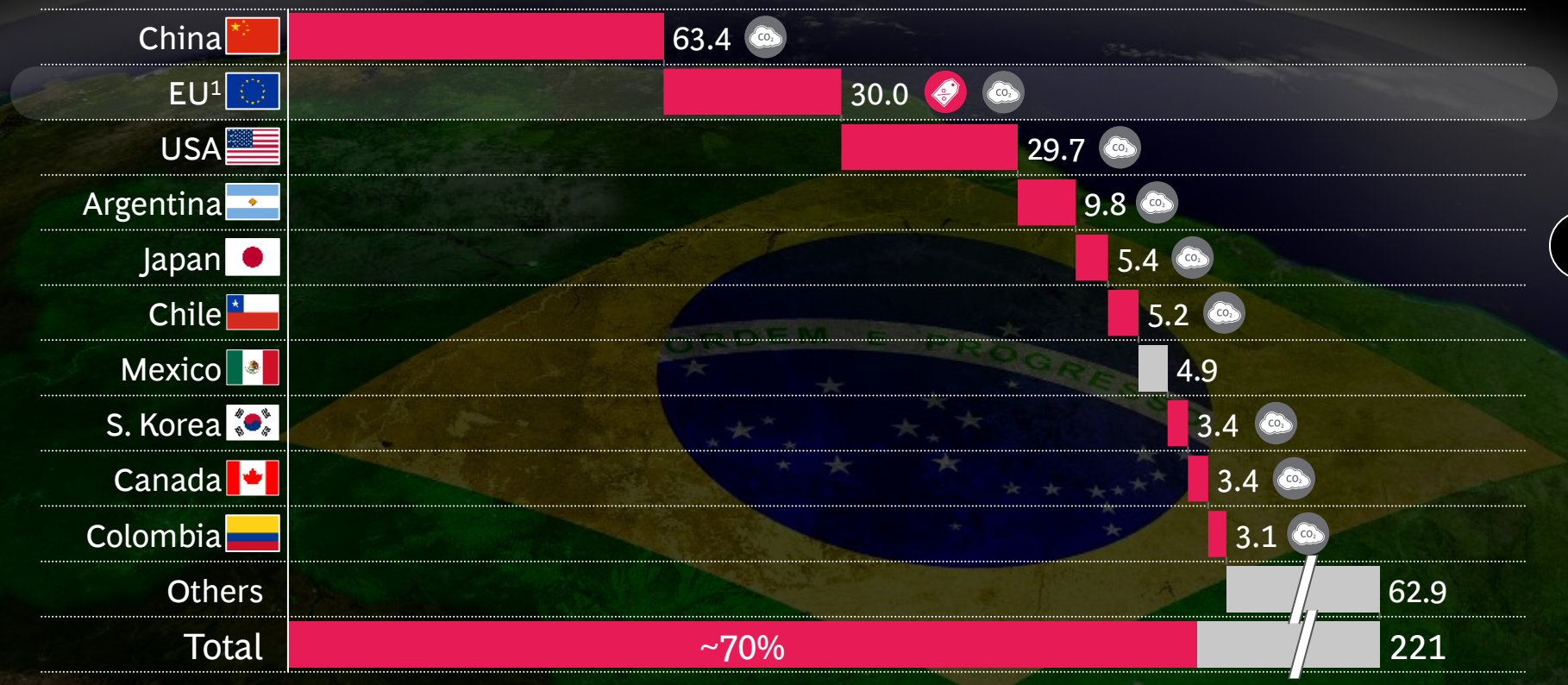
US$ **144** million
(R$ 742 million)
In additional tax revenues from the agricultural sector alone

Source: How Emerging Economies Can Pursue Green Recoveries; World Resources Institute 2020; BCG Analysis

Inaction can put a relevant part of BR exports at-risk...

Top 10 destinations of Brazilian exports

2019, in US$ Bn



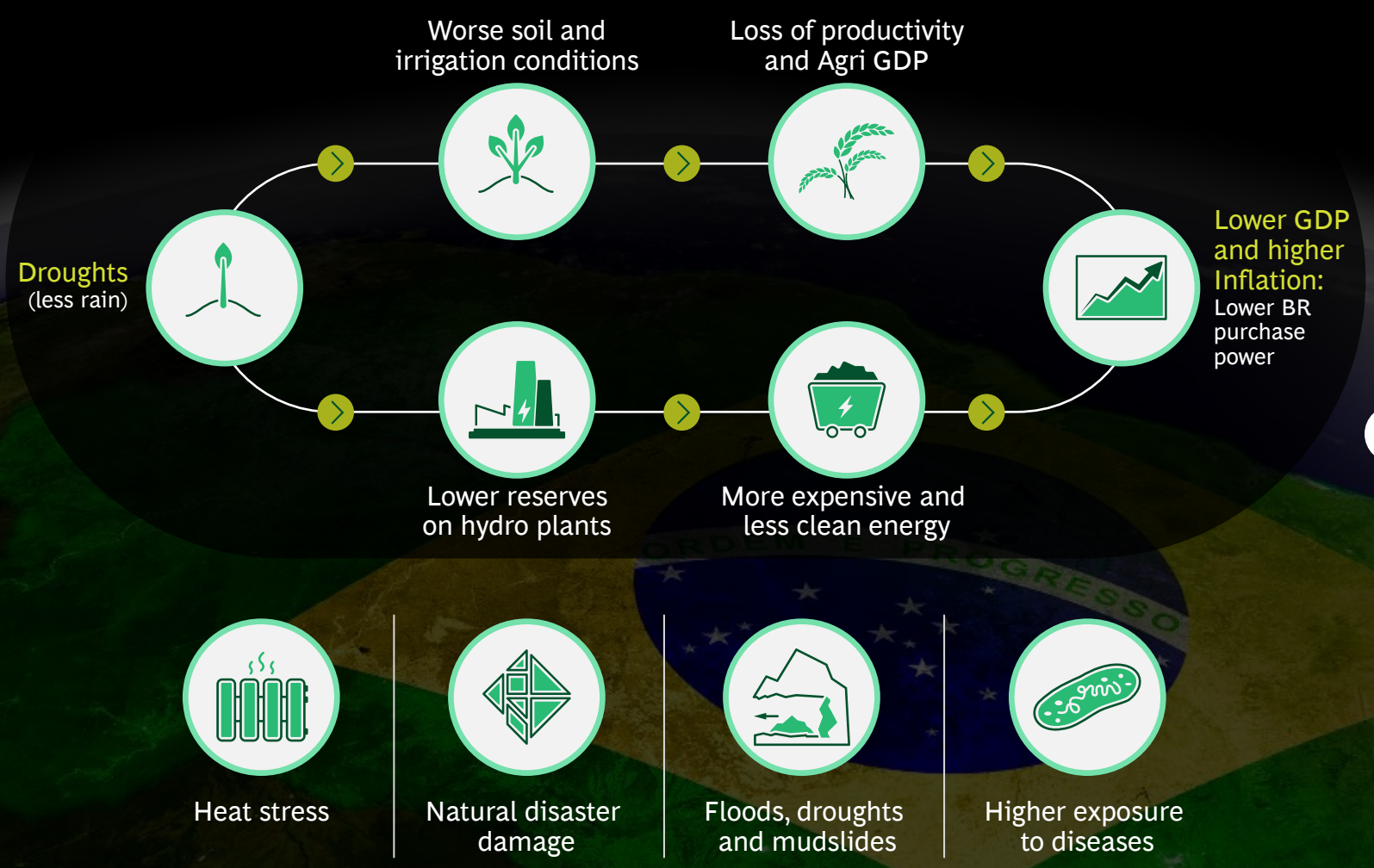
EU is implementing Carbon Border Tax (likely by 2023) and others may follow

Other core markets already announced NZ commitments

BR exports can be partially at risk by Carbon Border Taxes (bad reputation could impact even Brazil's "cleaner sectors")

1. European Union
Source: Comex Stat; World Bank; Climate Action Tracker; Press research; BCG analysis

… and cause unprecedent damage across BR economy



Up to 20% of farmland (33M Ha) lost by 2050

~51M people live in coastal and will likely need to relocate

~170M people exposed to malaria & other diseases by 2070

$350B yearly GDP lost (BR)

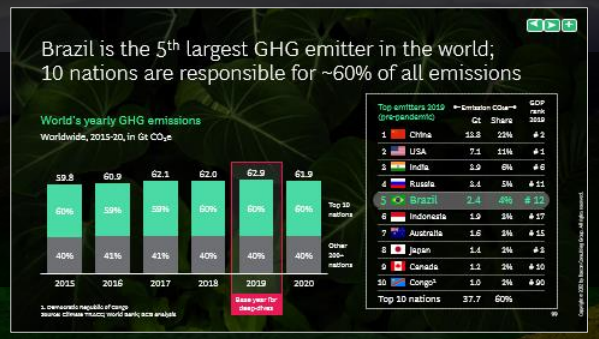
BR GDP loss due to climate effect on agriculture, heat stress & disasters damage

Source: Impacts of Climate Change on Brazilian Agriculture, World Bank 2013; Climate & Health Country Profile – Brazil, WHO 2015; IBGE; press search; BCG analysis

Diagnostic of BR GHG emissions

Brazil Climate Summit.

Understanding GHG emissions baseline for Brazil is key to coordinate actions and tackle the right issues



Brazil is the 5th largest emitter in the world

~70% of BR emissions come from AFOLU[1]

BR emits more GHG in AFOLU[1] than the entire world emits in Aviation

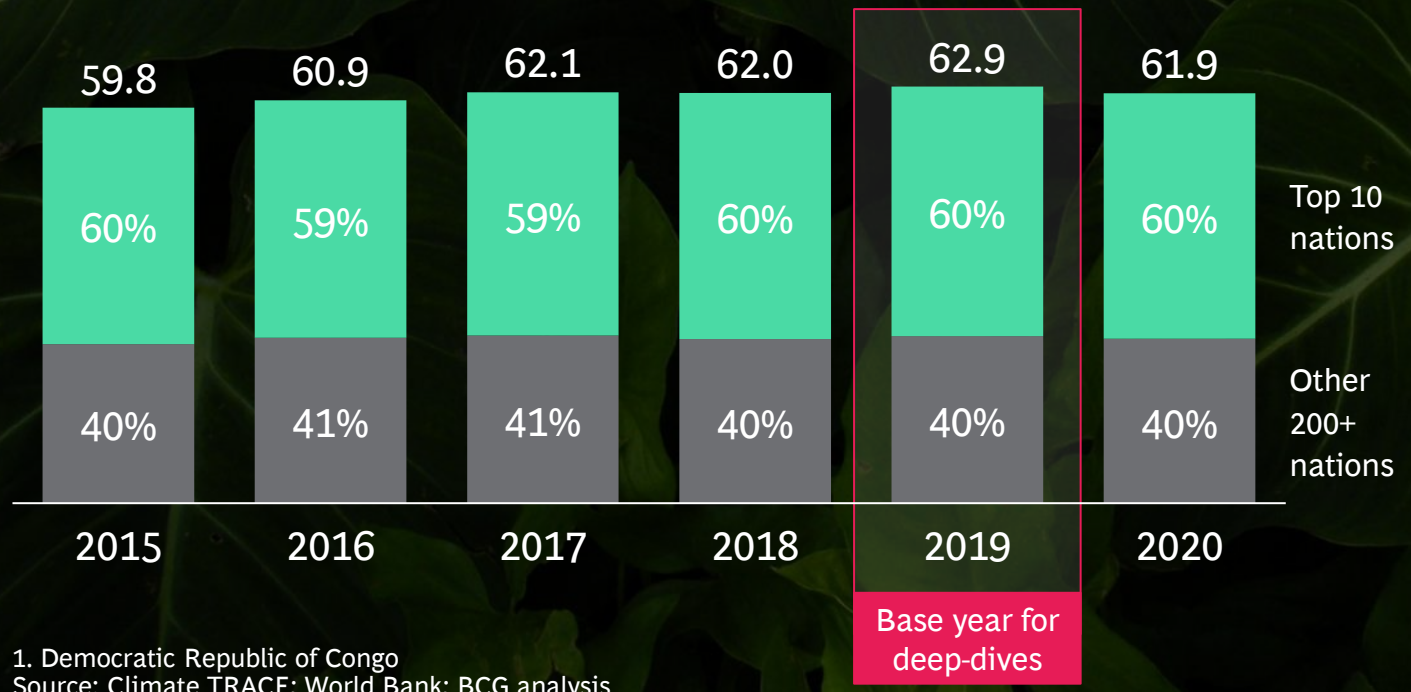
Tackling Forest emissions can solve ~50% of BR GHG issues and is a critical enabler for other sectors to unlock & create value from BR unique potential and natural resources

1. Agriculture, forestry & other land use
Source: Climate TRACE; BCG analysis

Brazil is the 5th largest GHG emitter in the world; 10 nations are responsible for ~60% of all emissions

World's yearly GHG emissions

Worldwide, 2015-20, in Gt CO_2e



Top emitters 2019 (pre-pandemic)		Emission CO_2e Gt	Emission CO_2e Share	GDP rank 2019
1	China	13.8	22%	# 2
2	USA	7.1	11%	# 1
3	India	3.9	6%	# 6
4	Russia	3.4	5%	# 11
5	Brazil	2.4	4%	# 12
6	Indonesia	1.9	3%	# 17
7	Australia	1.6	3%	# 15
8	Japan	1.4	2%	# 3
9	Canada	1.2	2%	# 10
10	Congo[1]	1.0	2%	# 90
Top 10 nations		37.7	60%	

1. Democratic Republic of Congo
Source: Climate TRACE; World Bank; BCG analysis

Brazil is the 5th largest GHG emitter, in absolute terms

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 10 ~60%

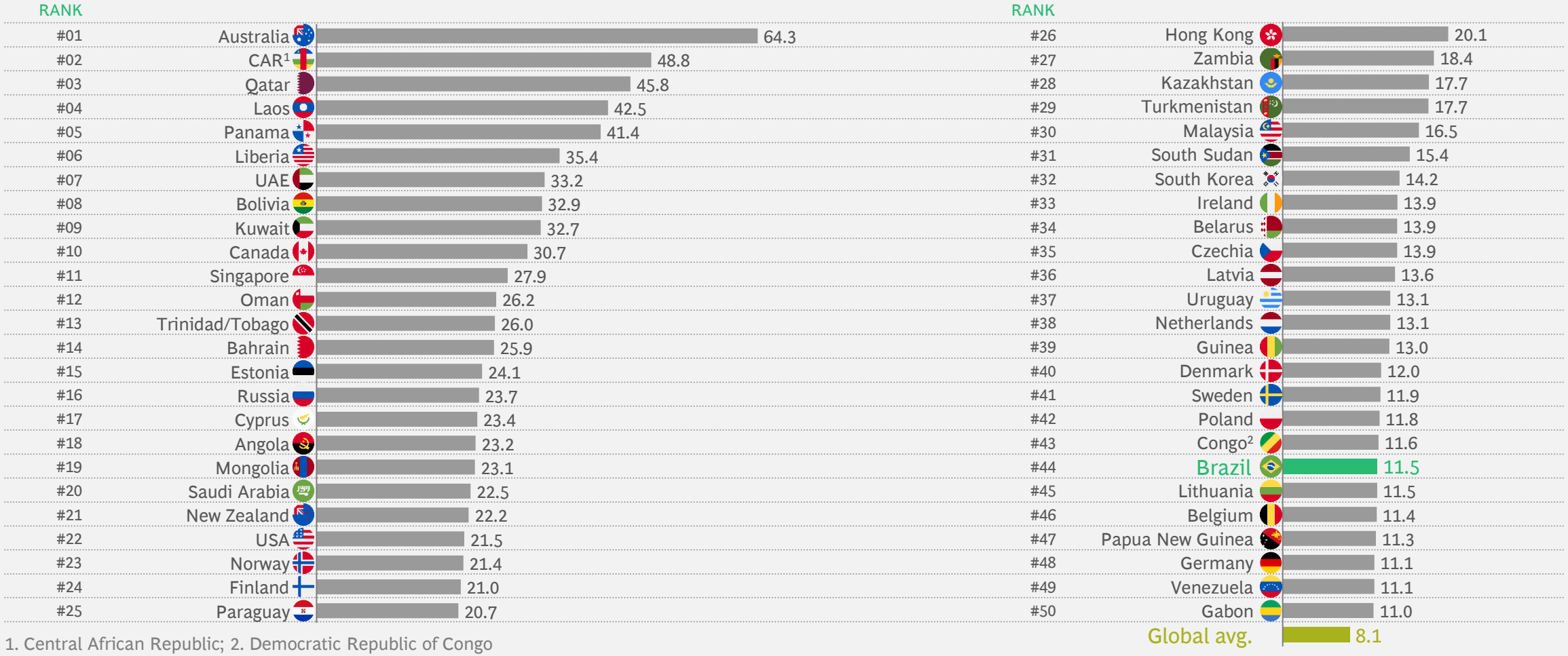
RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	China	13.8	21.9%	#26	Argentina	0.5	76.0%
#02	USA	7.1	33.2%	#27	Poland	0.4	76.7%
#03	India	3.9	39.4%	#28	Myanmar	0.4	77.4%
#04	Russia	3.4	44.8%	#29	Nigeria	0.4	78.1%
#05	Brazil	2.4	48.7%	#30	Bolivia	0.4	78.7%
#06	Indonesia	1.9	51.7%	#31	Spain	0.4	79.3%
#07	Australia	1.6	54.3%	#32	Bangladesh	0.4	79.8%
#08	Japan	1.4	56.4%	#33	Egypt	0.3	80.4%
#09	Canada	1.2	58.3%	#34	Kazakhstan	0.3	80.9%
#10	Congo[1]	1.0	59.9%	#35	Mozambique	0.3	81.4%
#11	Germany	0.9	61.3%	#36	Zambia	0.3	81.9%
#12	Mexico	0.8	62.7%	#37	UAE	0.3	82.5%
#13	Iran	0.8	64.0%	#38	Taiwan	0.3	83.0%
#14	Saudi Arabia	0.8	65.3%	#39	Venezuela	0.3	83.5%
#15	Angola	0.7	66.4%	#40	Colombia	0.3	84.0%
#16	South Korea	0.7	67.6%	#41	Laos	0.3	84.5%
#17	Thailand	0.6	68.5%	#42	Iraq	0.3	84.9%
#18	Vietnam	0.6	69.4%	#43	Philippines	0.3	85.4%
#19	South Africa	0.6	70.3%	#44	Ukraine	0.3	85.8%
#20	Turkey	0.5	71.2%	#45	Algeria	0.3	86.3%
#21	Pakistan	0.5	72.0%	#46	Tanzania	0.2	86.6%
#22	Malaysia	0.5	72.8%	#47	CAR[2]	0.2	87.0%
#23	France	0.5	73.6%	#48	Ethiopia	0.2	87.4%
#24	UK	0.5	74.5%	#49	Netherlands	0.2	87.7%
#25	Italy	0.5	75.3%	#50	Peru	0.2	88.0%
					Rest of the World	7.5	100%

1. Democratic Republic of Congo; 2. Central African Republic
Source: Climate TRACE; BCG analysis

Brazil is the 44th largest GHG emitter per capita

Yearly CO_2e emissions per capita – 50 most polluting countries (with population above 1MM)

2019, t CO_2e per inhabitant

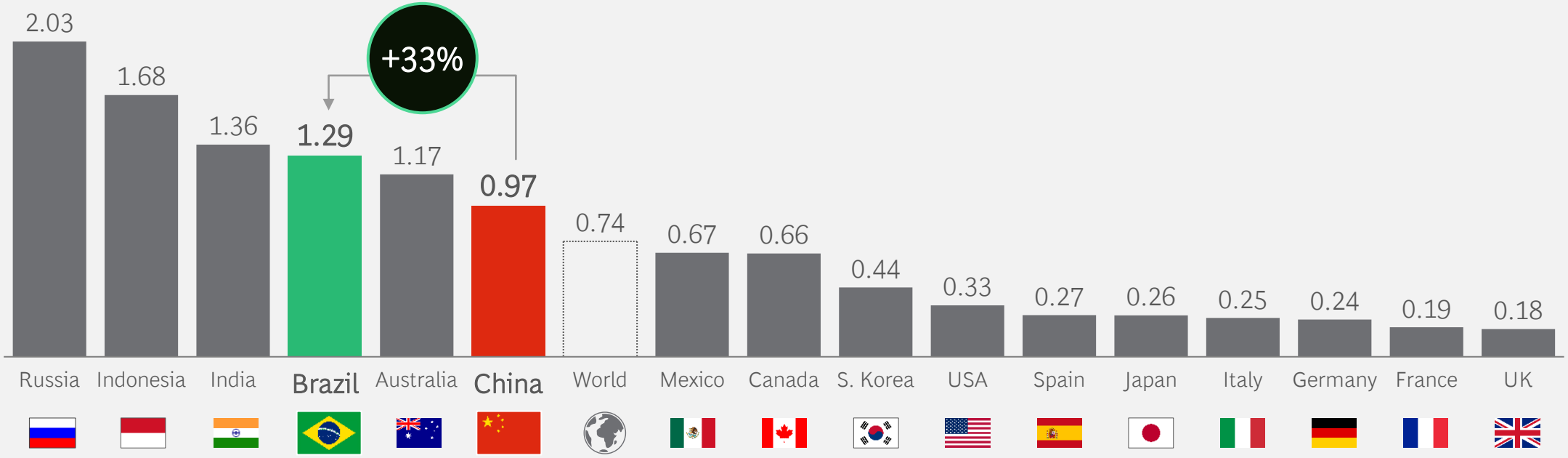


1. Central African Republic; 2. Democratic Republic of Congo
Source: Climate TRACE; World Bank; BCG analysis

Brazil emits more than China or USA, per dollar of GDP

GHG emissions per GDP – World's largest economies

For all economies with GDP > US$1 Tn, 2019, in kg CO_2e per US$ of GDP



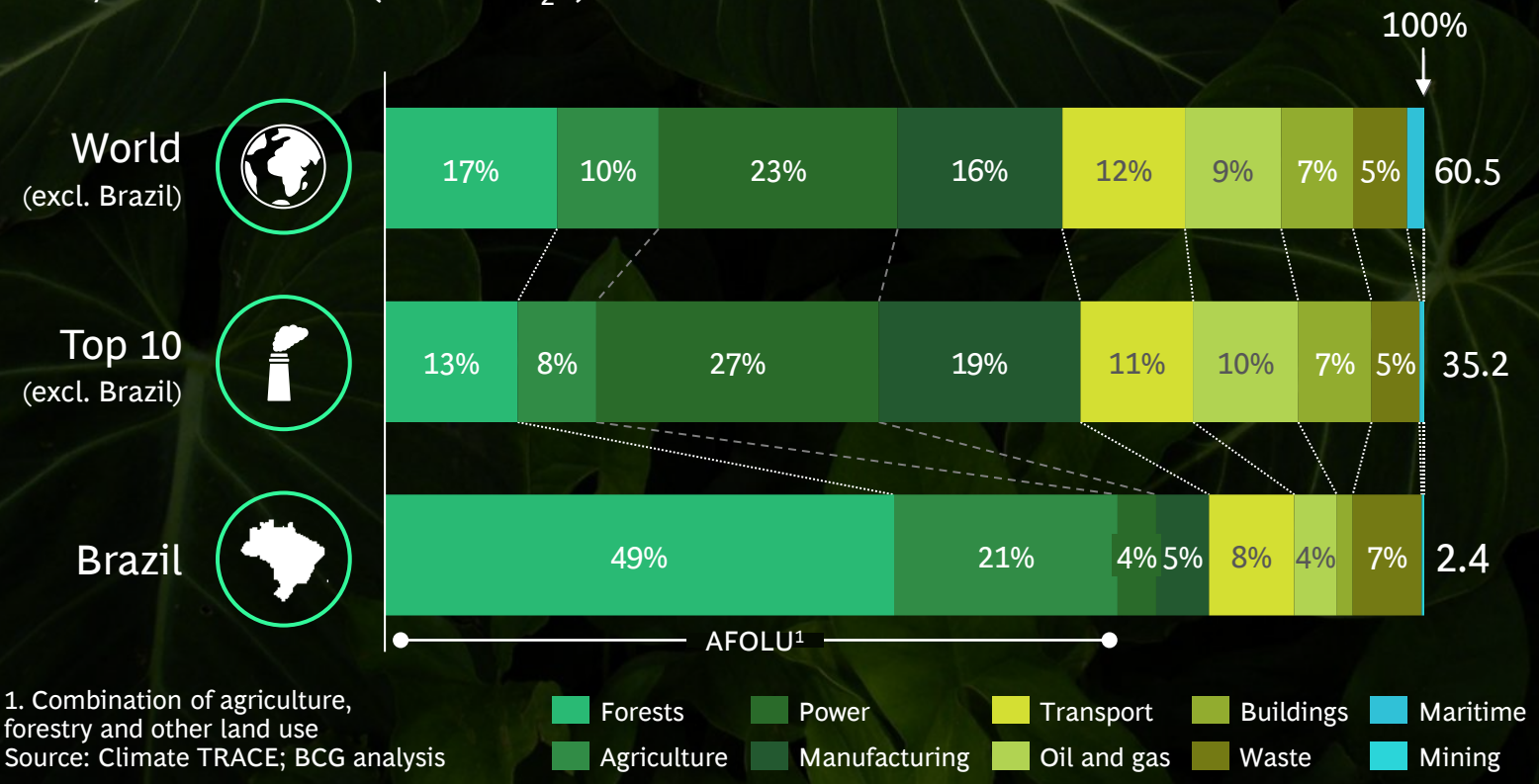
	Russia	Indonesia	India	Brazil	Australia	China	World	Mexico	Canada	S. Korea	USA	Spain	Japan	Italy	Germany	France	UK
2019 GDP (US$ Tn)	1.7	1.1	2.9	1.9	1.4	14.3	87.6	1.3	1.7	1.7	21.4	1.4	5.1	2.0	3.9	2.7	2.9

Source: Climate TRACE; World Bank; BCG analysis

Brazil's emissions & challenges highly differ from those in rest of the world

Total GHG emissions

2019, share of total (in Gt CO_2e)



1. Combination of agriculture, forestry and other land use
Source: Climate TRACE; BCG analysis

Other countries mainly struggle with:

Power
- ~1/3 of China's emissions
- ~1/4 of USA's emissions
- Only 4% of Brazil's emissions

Manufacturing
- ~1/3 of China's emissions
- Only 5% of Brazil's emissions

Brazil must focus on:

Forests (deforestation)
~1/2 of Brazil's emissions

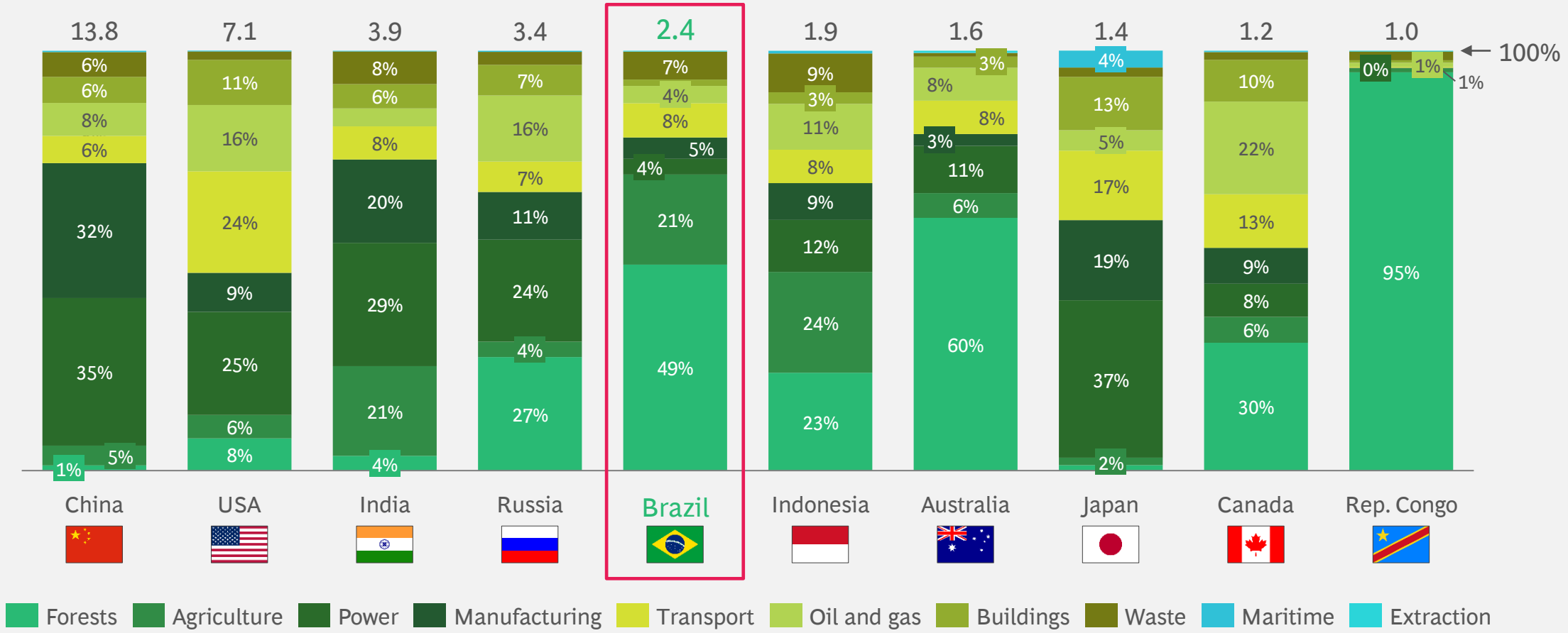
Agriculture (incl. meat)
~1/5 of Brazil's emissions

~70% of all Brazilian emissions

Brazil's emissions differ from other large emitters'

Top 10 countries – Greenhouse gas (GHG) emissions

Per country, 2019, share of total (in Gt CO_2e)

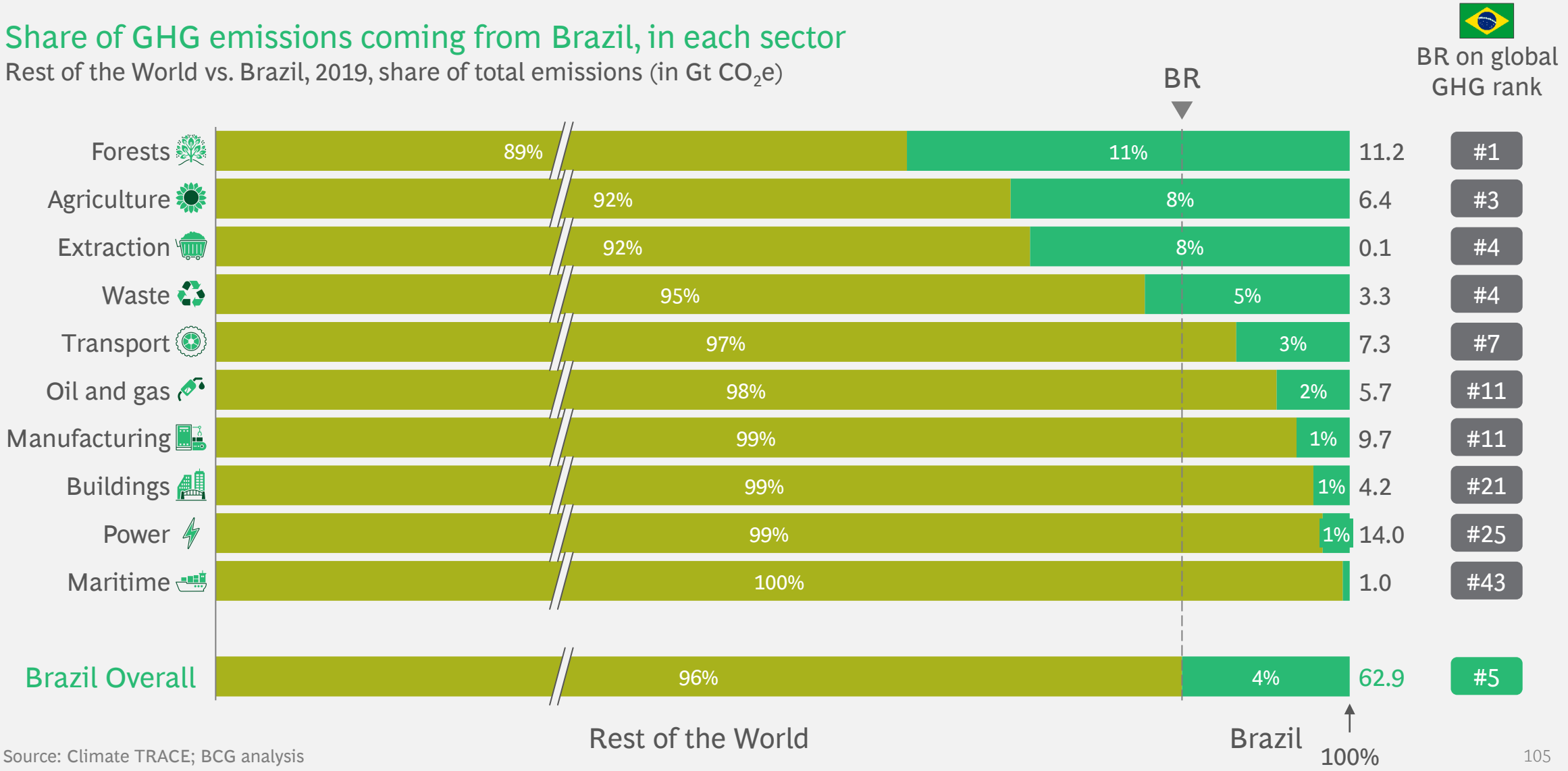


Source: Climate TRACE; BCG analysis

BR emits ~4% of world's GHG; share varies per sector

Share of GHG emissions coming from Brazil, in each sector

Rest of the World vs. Brazil, 2019, share of total emissions (in Gt CO_2e)



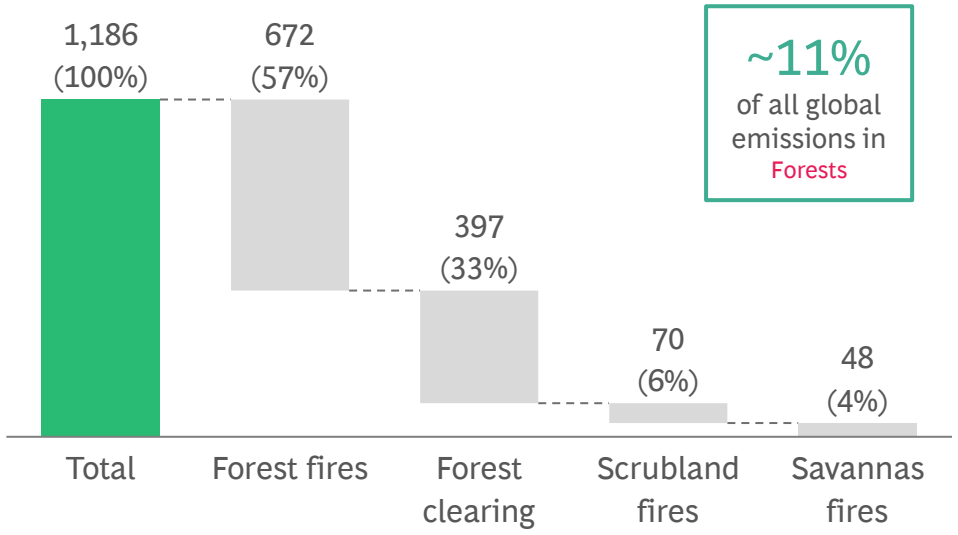
Source: Climate TRACE; BCG analysis

Deep-dive | Emissions by subsegments within Forests

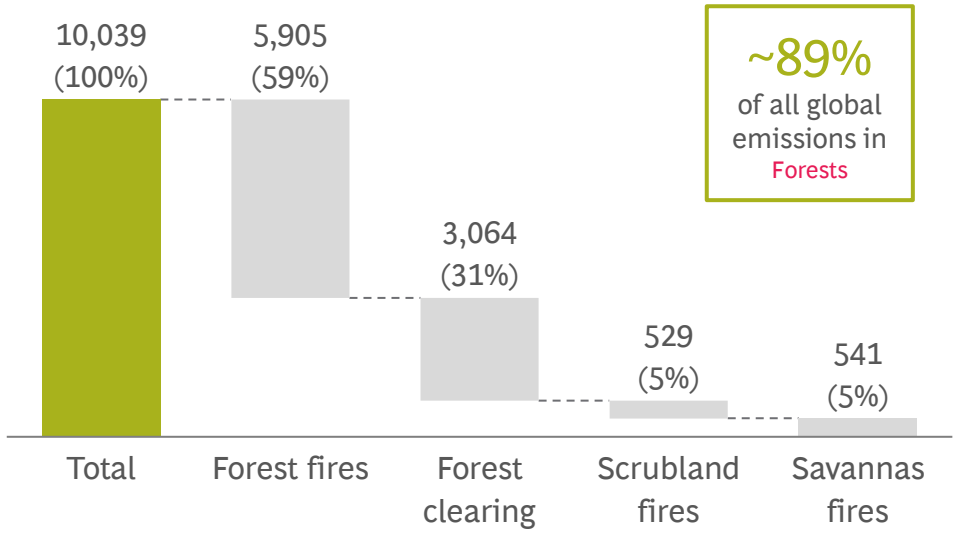
Emissions profile within Forests

2019, in Mt CO_2e

Brazil



Rest of the World (excluding Brazil)



Brazil, #1 polluter in Forests, is responsible alone for ~11% of all global emissions in this sector.
Similar profiles in Brazil and RoW: ~60% of the emissions come from forest fires & ~30% from forest clearing.

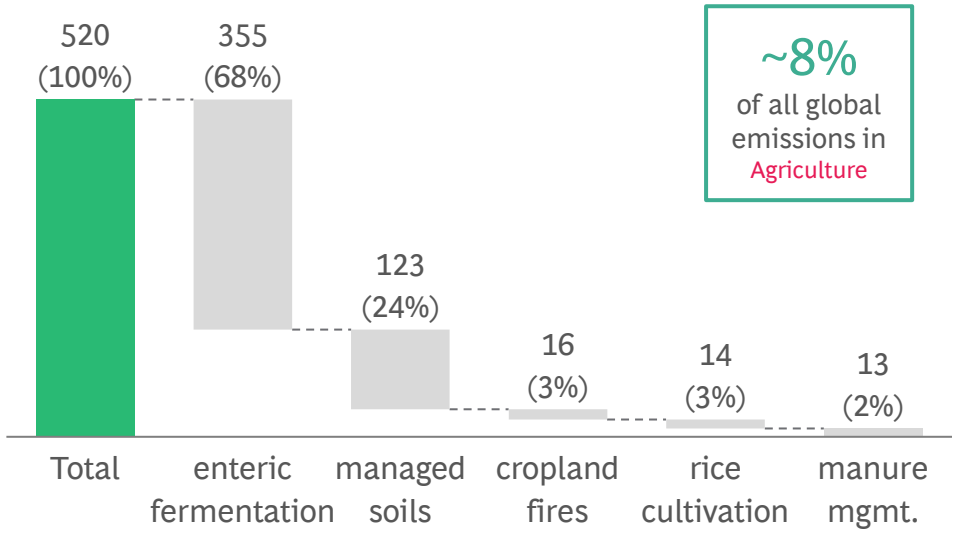
Source: Climate TRACE; BCG analysis

Deep-dive | Emissions by subsegments within Agriculture

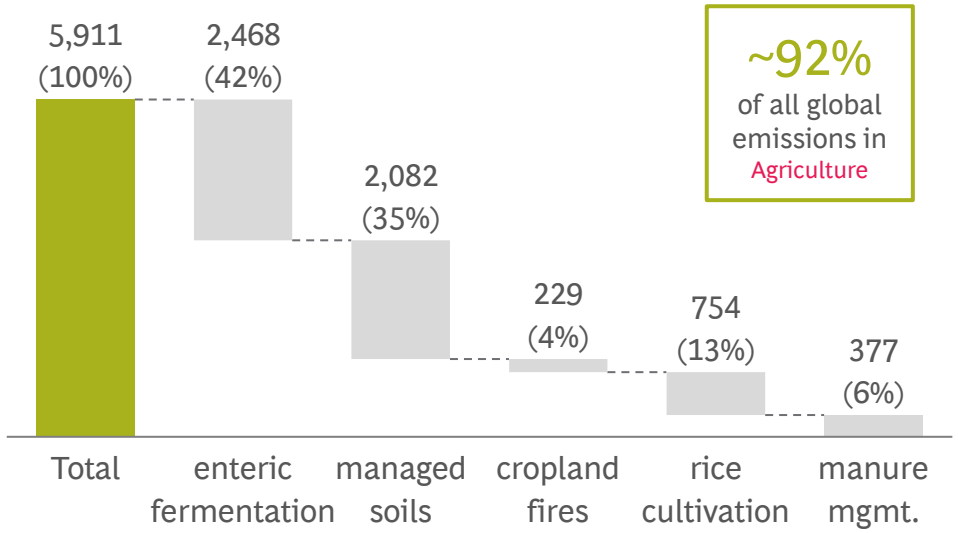
Emissions profile within Agriculture

2019, in Mt CO_2e

Brazil



Rest of the World (excluding Brazil)



Brazil is responsible for ~8% of all global emissions in the sector. BR emissions are more concentrated in enteric fermentation (68%) when compared to RoW (42%) and less in managed soils (24% vs 35%).

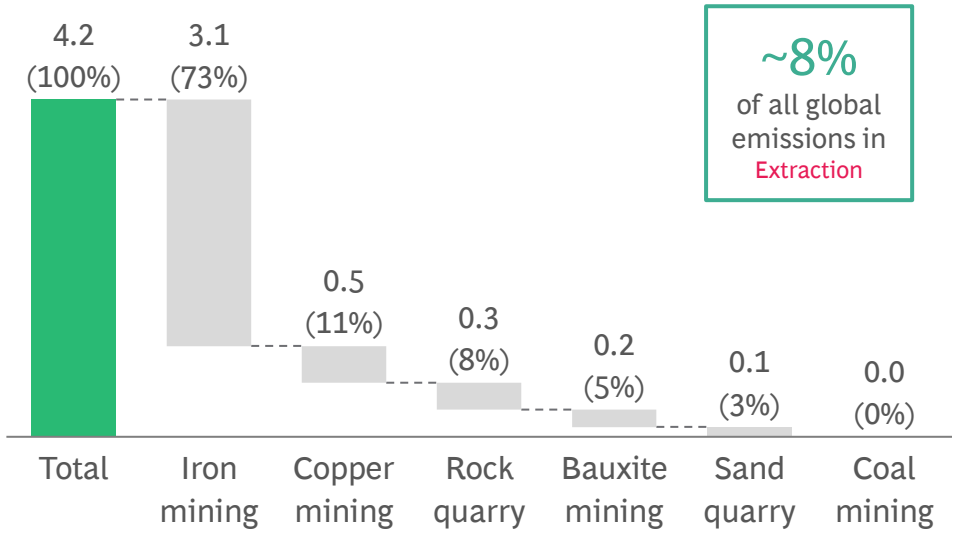
Source: Climate TRACE; BCG analysis

Deep-dive | Emissions by subsegments within Mineral Extraction (Mining)

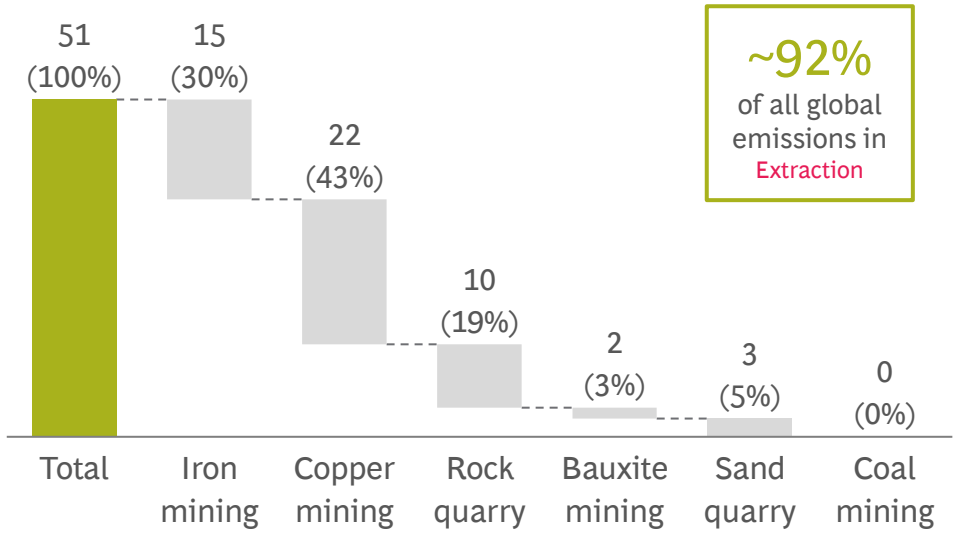
Emissions profile within Mineral Extraction (Mining)

2019, in Mt CO_2e

Brazil



Rest of the World (excluding Brazil)



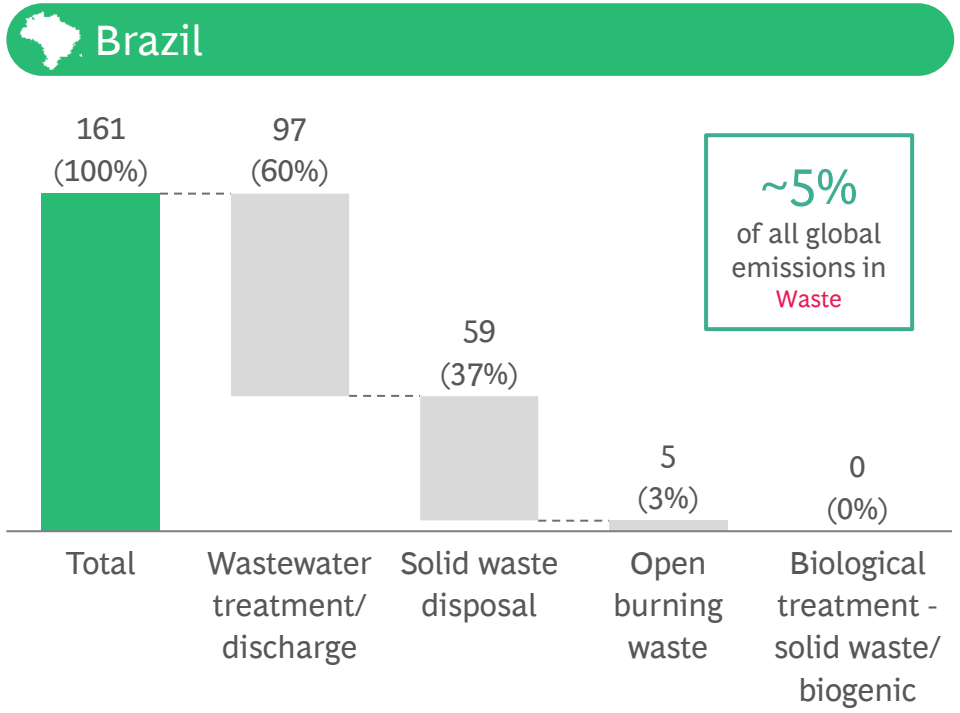
Brazil is responsible for ~8% of all global emissions in the sector. BR emissions are more concentrated in iron mining (73%) when compared to RoW (30%) and less in copper mining (11% vs 43%).

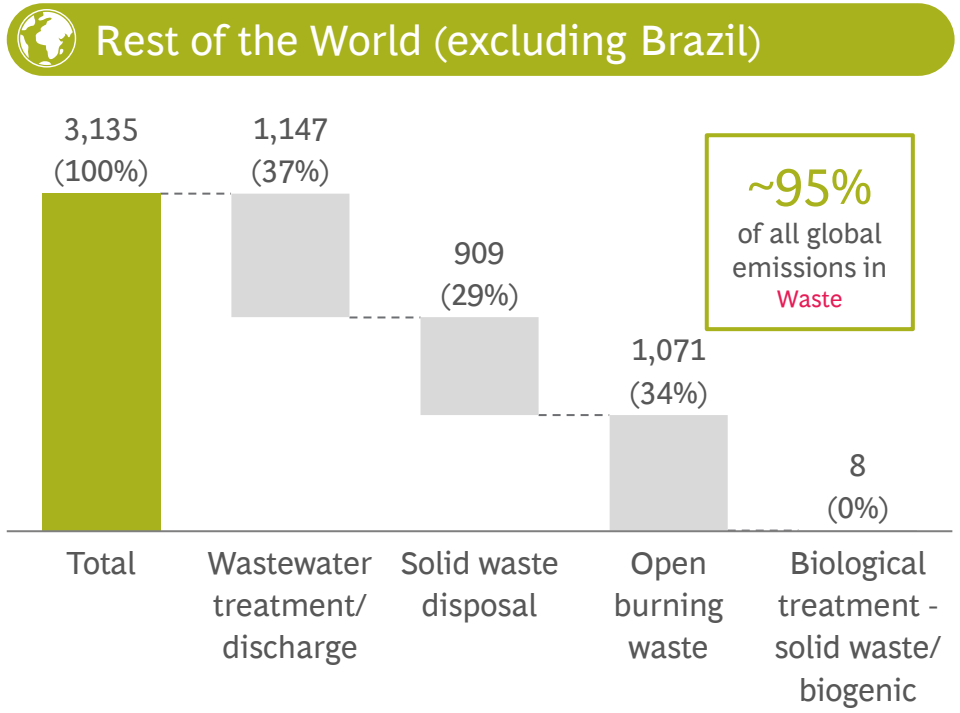
Source: Climate TRACE; BCG analysis

Deep-dive | Emissions by subsegments within Waste

Emissions profile within Waste

2019, in Mt CO_2e





Brazil is responsible for ~5% of all global emissions in the sector. BR emissions are more concentrated in wastewater (60%) when compared to RoW (37%) and less in open burning waste (3% vs 34%).

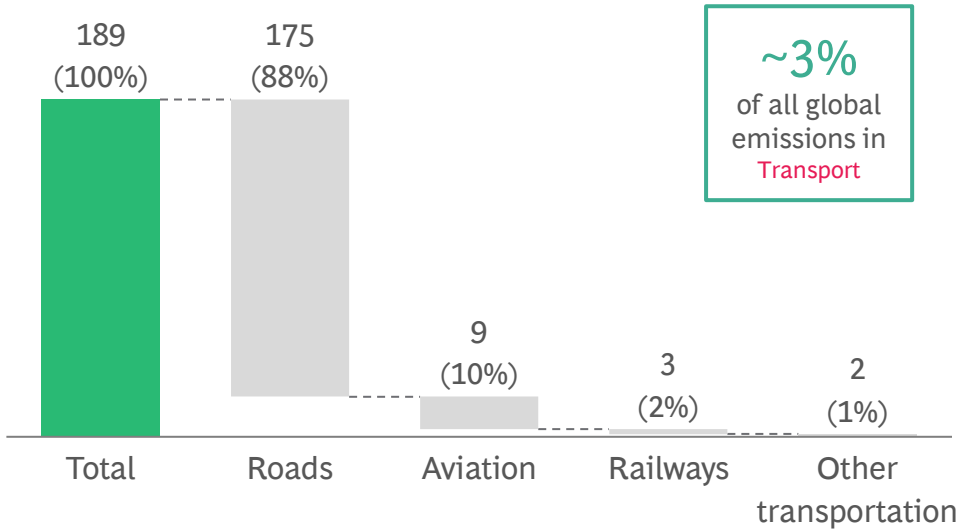
Source: Climate TRACE; BCG analysis

Deep-dive | Emissions by subsegments within Transport

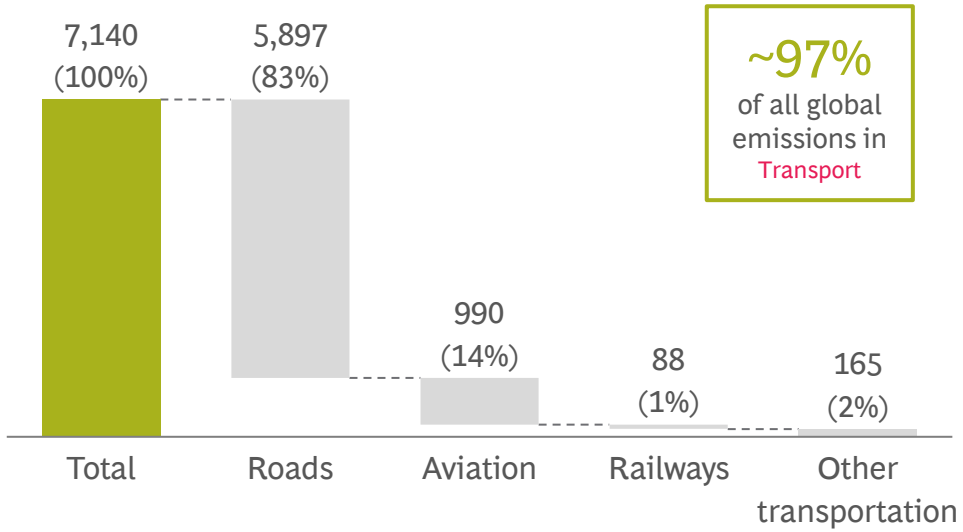
Emissions profile within Transport

2019, in Mt CO_2e

Brazil



Rest of the World (excluding Brazil)



Brazil is responsible for ~3% of all global emissions in the sector. BR and RoW emissions are more concentrated in roads (88% and 83%). Other categories are less relevant.

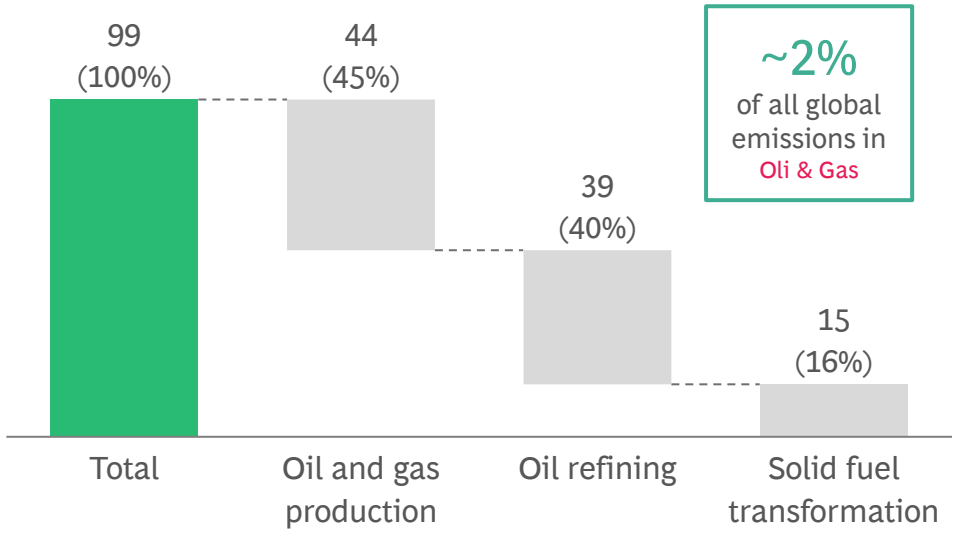
Source: Climate TRACE; BCG analysis

Deep-dive | Emissions by subsegments within Oil & Gas

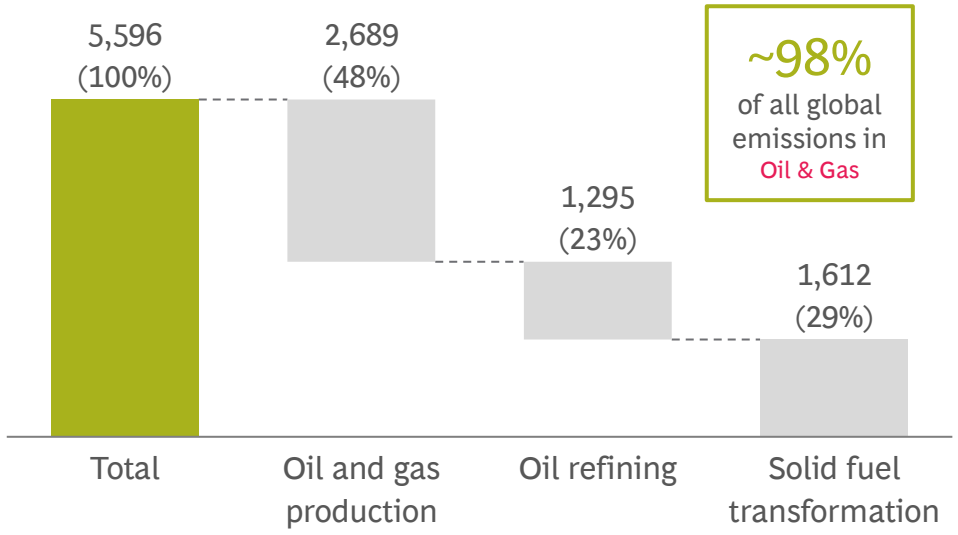
Emissions profile within Oil & Gas

2019, in Mt CO_2e

Brazil



Rest of the World (excluding Brazil)



Brazil is responsible for ~2% of all global emissions in the sector. BR emissions are more concentrated in oil refining (40%) when compared to RoW (23%) and less in solid fuel transformation (16% vs 29%).

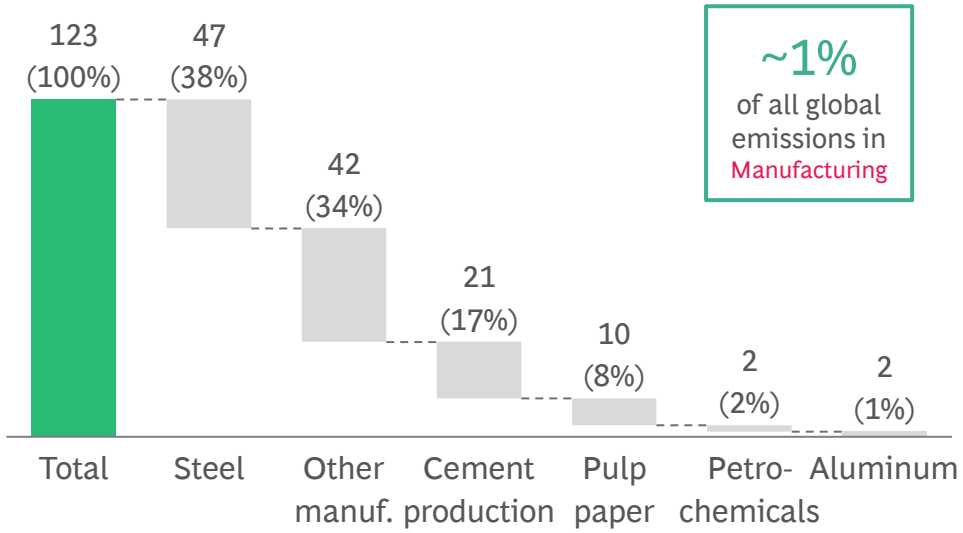
Source: Climate TRACE; BCG analysis

Deep-dive | Emissions by subsegments within Manufacturing

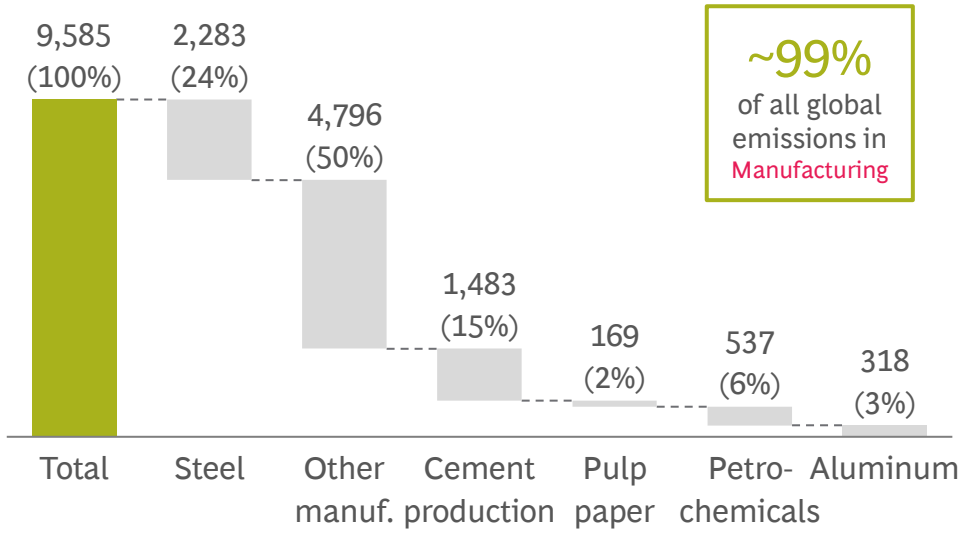
Emissions profile within Manufacturing

2019, in Mt CO_2e

Brazil



Rest of the World (excluding Brazil)



Brazil is responsible for ~1% of all global emissions in the sector. BR emissions are more concentrated in steel (38%) when compared to RoW (24%). Other manufacturing and cement are relevant across.

Source: Climate TRACE; BCG analysis

Globally, 3 sectors are responsible for ~55% of emissions

Global GHG emissions per sector (2015-2020) in Gt CO_2e

XX% Sector's contribution to total global emissions

Source: Climate TRACE; World Bank; BCG analysis

World's Top 5 GHG polluters by segment

Top 5 GHG emitters (and Brazil) by sector, in 2019

Power

	Gt Co_2e	Share
#1 China	4.85	35%
#2 USA	1.74	12%
#3 India	1.15	8%
#4 Russia	0.83	6%
#5 Japan	0.51	4%
#25 Brazil	0.09	<1%

Forests

	Gt Co_2e	Share
#1 Brazil	1.19	11%
#2 Australia	0.98	9%
#3 Congo[1]	0.96	9%
#4 Russia	0.92	8%
#5 Angola	0.67	6%

Manufacturing

	Gt Co_2e	Share
#1 China	4.44	46%
#2 India	0.78	8%
#3 USA	0.66	7%
#4 Russia	0.39	4%
#5 Japan	0.26	3%
#11 Brazil	0.12	1%

Transport

	Gt Co_2e	Share
#1 USA	1.71	23%
#2 China	0.89	12%
#3 India	0.31	4%
#4 Russia	0.25	3%
#5 Japan	0.23	3%
#7 Brazil	0.20	3%

Agriculture

	Gt Co_2e	Share
#1 India	0.84	13%
#2 China	0.65	10%
#3 Brazil	0.52	8%
#4 Indonesia	0.45	7%
#5 USA	0.40	6%

Oil & Gas

	Gt Co_2e	Share
#1 USA	1.12	20%
#2 China	1.08	19%
#3 Russia	0.54	9%
#4 Canada	0.26	4%
#5 Indonesia	0.21	4%
#11 Brazil	0.10	2%

Buildings

	Gt Co_2e	Share
#1 China	0.86	20%
#2 USA	0.76	18%
#3 Russia	0.25	6%
#4 India	0.23	5%
#5 Japan	0.17	4%
#21 Brazil	0.04	1%

Waste

	Gt Co_2e	Share
#1 China	0.82	25%
#2 India	0.31	9%
#3 Indonesia	0.17	5%
#4 Brazil	0.16	5%
#5 USA	0.14	4%

Maritime

	Gt Co_2e	Share
#1 Panama	0.14	15%
#2 Liberia	0.10	11%
#3 Marshall Isl.	0.09	9%
#4 Hong Kong	0.08	9%
#5 Singapore	0.06	7%
#43 Brazil	0.00	<1%

Mining

	Mt Co_2e	Share
#1 China	9.20	17%
#2 Australia	8.42	15%
#3 Chile	6.87	12%
#4 Brazil	4.20	8%
#5 USA	3.56	6%

1. Democratic Republic of Congo
Source: Climate TRACE; BCG analysis

Typically, a few countries contribute to ~60% of all GHG

Cumulative share (up to 60%) of global GHG emissions, in 2019 (%)

Power

China	34.6%
USA	47.0%
India	55.2%
Russia	61.2%

Forests

Brazil	10.6%
Australia	19.3%
Congo	27.8%
Russia	36.1%
Angola	42.1%
USA	46.9%
Indonesia	50.8%
Canada	53.9%
Bolivia	56.8%
Mozambique	59.4%
Zambia	61.9%

Manufacturing

China	45.7%
India	53.7%
USA	60.5%

Transport

USA	23.3%
China	35.5%
India	39.7%
Russia	43.1%
Japan	46.2%
Germany	49.0%
Brazil	51.7%
Mexico	53.9%
France	56.1%
UK	58.1%
Indonesia	60.2%

Agriculture

India	13.0%
China	23.1%
Brazil	31.2%
Indonesia	38.2%
USA	44.4%
Pakistan	47.6%
Bangladesh	49.7%
Argentina	51.8%
Russia	53.7%
Myanmar	55.5%
Ethiopia	57.3%
Mexico	58.9%
Australia	60.4%

Oil & Gas

USA	19.6%
China	38.6%
Russia	48.1%
Canada	52.6%
Indonesia	56.2%
Iran	59.6%

Buildings

China	20.3%
USA	38.3%
Russia	44.2%
India	49.6%
Japan	53.7%
Germany	57.1%
Iran	60.4%

Waste

China	24.8%
India	34.1%
Indonesia	39.3%
Brazil	44.2%
USA	48.6%
Russia	51.7%
Bangladesh	54.7%
Thailand	57.5%
Vietnam	59.8%

Maritime

Panama	15.2%
Liberia	26.0%
Marshall Islands	35.5%
Hong Kong	44.3%
Singapore	50.9%
Malta	56.7%
Japan	62.5%

Mining

China	16.7%
Australia	32.0%
Chile	44.5%
Brazil	52.1%
USA	58.6%
India	62.7%

Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Power – Brazil is #25

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 4 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	China	4.85	34.6%	#26	UAE	0.09	88.0%
#02	USA	1.74	47.0%	#27	Ukraine	0.09	88.7%
#03	India	1.15	55.2%	#28	UK	0.08	89.3%
#04	Russia	0.83	61.2%	#29	Pakistan	0.08	89.8%
#05	Japan	0.51	64.8%	#30	Philippines	0.07	90.3%
#06	South Korea	0.32	67.1%	#31	Spain	0.06	90.8%
#07	Saudi Arabia	0.27	69.0%	#32	Netherlands	0.05	91.2%
#08	Germany	0.26	70.9%	#33	Czechia	0.05	91.5%
#09	Indonesia	0.23	72.6%	#34	Argentina	0.05	91.9%
#10	South Africa	0.22	74.1%	#35	France	0.05	92.2%
#11	Australia	0.18	75.4%	#36	Kuwait	0.04	92.5%
#12	Iran	0.16	76.6%	#37	Uzbekistan	0.04	92.8%
#13	Taiwan	0.16	77.7%	#38	Algeria	0.04	93.1%
#14	Mexico	0.15	78.8%	#39	Bangladesh	0.04	93.4%
#15	Poland	0.14	79.9%	#40	Israel	0.04	93.7%
#16	Turkey	0.13	80.8%	#41	Chile	0.04	93.9%
#17	Malaysia	0.12	81.6%	#42	Belarus	0.03	94.1%
#18	Vietnam	0.12	82.5%	#43	Singapore	0.03	94.3%
#19	Egypt	0.11	83.3%	#44	Venezuela	0.03	94.5%
#20	Thailand	0.11	84.0%	#45	Morocco	0.03	94.7%
#21	Italy	0.10	84.8%	#46	Hong Kong	0.03	94.9%
#22	Kazakhstan	0.10	85.5%	#47	Serbia	0.03	95.1%
#23	Iraq	0.09	86.1%	#48	Greece	0.03	95.3%
#24	Canada	0.09	86.8%	#49	Romania	0.02	95.5%
#25	Brazil	0.09	87.4%	#50	Qatar	0.02	95.6%
					Rest of the World	0.61	100%

Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Forest – Brazil is #1

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 11 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	Brazil	1.19	10.6%	#26	Peru	0.10	82.4%
#02	Australia	0.98	19.3%	#27	Cameroon	0.08	83.1%
#03	Congo[1]	0.96	27.8%	#28	Argentina	0.08	83.9%
#04	Russia	0.92	36.1%	#29	Thailand	0.08	84.6%
#05	Angola	0.67	42.1%	#30	Côte d'Ivoire	0.08	85.3%
#06	USA	0.54	46.9%	#31	Vietnam	0.08	86.0%
#07	Indonesia	0.44	50.8%	#32	Nigeria	0.07	86.7%
#08	Canada	0.35	53.9%	#33	Cambodia	0.07	87.3%
#09	Bolivia	0.32	56.8%	#34	Sierra Leone	0.07	87.9%
#10	Mozambique	0.29	59.4%	#35	Liberia	0.07	88.5%
#11	Zambia	0.28	61.9%	#36	Ghana	0.06	89.1%
#12	Laos	0.26	64.2%	#37	Ethiopia	0.06	89.6%
#13	Myanmar	0.24	66.3%	#38	Papua New Guinea	0.06	90.1%
#14	CAR[2]	0.22	68.3%	#39	South Africa	0.06	90.6%
#15	Mexico	0.17	69.8%	#40	Sweden	0.05	91.0%
#16	China	0.17	71.3%	#41	Chad	0.05	91.4%
#17	Malaysia	0.16	72.7%	#42	Germany	0.04	91.8%
#18	Tanzania	0.14	74.0%	#43	Finland	0.04	92.1%
#19	India	0.14	75.2%	#44	Congo	0.04	92.5%
#20	South Sudan	0.13	76.4%	#45	Honduras	0.04	92.8%
#21	Guinea	0.13	77.6%	#46	Philippines	0.03	93.0%
#22	Colombia	0.12	78.6%	#47	Zimbabwe	0.03	93.3%
#23	Madagascar	0.12	79.6%	#48	Sudan	0.03	93.6%
#24	Venezuela	0.10	80.6%	#49	France	0.03	93.8%
#25	Paraguay	0.10	81.5%	#50	Kazakhstan	0.03	94.1%
					Rest of the World	0.67	100%

1. Democratic Republic of Congo; 2. Central African Republic
Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Manufacturing – Brazil is #11

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 3 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	China	4.44	45.7%	#26	Italy	0.05	88.7%
#02	India	0.78	53.7%	#27	Spain	0.05	89.3%
#03	USA	0.66	60.5%	#28	Poland	0.05	89.8%
#04	Russia	0.39	64.5%	#29	Ukraine	0.05	90.3%
#05	Japan	0.26	67.2%	#30	Australia	0.05	90.7%
#06	Saudi Arabia	0.20	69.2%	#31	Argentina	0.04	91.1%
#07	Indonesia	0.16	70.9%	#32	Netherlands	0.04	91.5%
#08	Iran	0.15	72.5%	#33	Philippines	0.03	91.8%
#09	Germany	0.14	73.9%	#34	Qatar	0.03	92.2%
#10	South Korea	0.13	75.2%	#35	Venezuela	0.03	92.5%
#11	Brazil	0.12	76.5%	#36	Bangladesh	0.03	92.8%
#12	Vietnam	0.12	77.7%	#37	Oman	0.03	93.1%
#13	Mexico	0.11	78.9%	#38	Belgium	0.03	93.4%
#14	Turkey	0.11	80.0%	#39	Algeria	0.03	93.6%
#15	Canada	0.10	81.0%	#40	Kuwait	0.02	93.9%
#16	UAE	0.08	81.9%	#41	Singapore	0.02	94.1%
#17	Thailand	0.08	82.7%	#42	Romania	0.02	94.3%
#18	Pakistan	0.08	83.5%	#43	Colombia	0.02	94.6%
#19	Egypt	0.07	84.3%	#44	Nigeria	0.02	94.8%
#20	Kazakhstan	0.07	85.0%	#45	Austria	0.02	94.9%
#21	France	0.06	85.7%	#46	Czechia	0.02	95.1%
#22	South Africa	0.06	86.3%	#47	Trinidade/Tobago	0.02	95.3%
#23	Malaysia	0.06	87.0%	#48	Uzbekistan	0.02	95.5%
#24	Taiwan	0.06	87.6%	#49	Iraq	0.02	95.6%
#25	UK	0.06	88.2%	#50	Norway	0.01	95.8%
					Rest of the World	0.41	100%

Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Transport – Brazil is #7

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 11 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	USA	1.71	23.3%	#26	South Africa	0.06	80.8%
#02	China	0.89	35.5%	#27	Egypt	0.06	81.6%
#03	India	0.31	39.7%	#28	Argentina	0.05	82.2%
#04	Russia	0.25	43.1%	#29	Algeria	0.05	82.9%
#05	Japan	0.23	46.2%	#30	Vietnam	0.05	83.5%
#06	Germany	0.21	49.0%	#31	Taiwan	0.04	84.1%
#07	Brazil	0.20	51.7%	#32	Netherlands	0.04	84.7%
#08	Mexico	0.16	53.9%	#33	Philippines	0.04	85.2%
#09	France	0.16	56.1%	#34	Colombia	0.04	85.7%
#10	UK	0.15	58.1%	#35	Iraq	0.03	86.1%
#11	Indonesia	0.15	60.2%	#36	Venezuela	0.03	86.6%
#12	Canada	0.15	62.2%	#37	Belgium	0.03	87.0%
#13	Italy	0.15	64.2%	#38	Chile	0.03	87.4%
#14	Iran	0.14	66.1%	#39	Ukraine	0.03	87.7%
#15	Australia	0.13	67.9%	#40	Peru	0.03	88.1%
#16	Saudi Arabia	0.12	69.6%	#41	Qatar	0.03	88.5%
#17	South Korea	0.12	71.1%	#42	Hong Kong	0.03	88.8%
#18	Spain	0.11	72.7%	#43	Switzerland	0.02	89.2%
#19	Poland	0.09	74.0%	#44	Austria	0.02	89.5%
#20	Turkey	0.09	75.2%	#45	Portugal	0.02	89.8%
#21	Thailand	0.09	76.5%	#46	Israel	0.02	90.1%
#22	Nigeria	0.07	77.4%	#47	Sweden	0.02	90.4%
#23	Malaysia	0.07	78.3%	#48	Singapore	0.02	90.7%
#24	UAE	0.06	79.2%	#49	Ecuador	0.02	90.9%
#25	Pakistan	0.06	80.0%	#50	Czechia	0.02	91.2%
					Rest of the World	0.64	100%

Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Agriculture – Brazil is #3

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 13 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	India	0.84	13.0%	#26	Kenya	0.05	73.9%
#02	China	0.65	23.1%	#27	Turkey	0.05	74.7%
#03	Brazil	0.52	31.2%	#28	Ukraine	0.04	75.4%
#04	Indonesia	0.45	38.2%	#29	New Zealand	0.04	76.0%
#05	USA	0.40	44.4%	#30	Poland	0.04	76.7%
#06	Pakistan	0.20	47.6%	#31	Belarus	0.04	77.3%
#07	Bangladesh	0.13	49.7%	#32	Venezuela	0.04	78.0%
#08	Argentina	0.13	51.8%	#33	Spain	0.04	78.5%
#09	Russia	0.13	53.7%	#34	Uganda	0.04	79.1%
#10	Myanmar	0.12	55.5%	#35	South Sudan	0.04	79.7%
#11	Ethiopia	0.12	57.3%	#36	Uzbekistan	0.04	80.2%
#12	Mexico	0.10	58.9%	#37	Papua New Guinea	0.03	80.8%
#13	Australia	0.10	60.4%	#38	Philippines	0.03	81.3%
#14	Nigeria	0.09	61.7%	#39	Mali	0.03	81.8%
#15	Vietnam	0.08	62.9%	#40	Cambodia	0.03	82.3%
#16	France	0.08	64.1%	#41	Mongolia	0.03	82.8%
#17	Thailand	0.07	65.3%	#42	Zambia	0.03	83.2%
#18	Sudan	0.07	66.4%	#43	Iran	0.03	83.7%
#19	Canada	0.07	67.5%	#44	Italy	0.03	84.2%
#20	Chad	0.07	68.6%	#45	Niger	0.03	84.7%
#21	Germany	0.07	69.6%	#46	Paraguay	0.03	85.2%
#22	Colombia	0.06	70.6%	#47	Egypt	0.03	85.6%
#23	Tanzania	0.06	71.5%	#48	South Africa	0.03	86.1%
#24	Malaysia	0.06	72.4%	#49	Kazakhstan	0.03	86.5%
#25	UK	0.05	73.2%	#50	Nepal	0.03	86.9%
					Rest of the World	0.84	100%

Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Oil & Gas – Brazil is #11

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 6 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	USA	1.12	19.6%	#26	Germany	0.04	86.1%
#02	China	1.08	38.6%	#27	UK	0.04	86.7%
#03	Russia	0.54	48.1%	#28	Uzbekistan	0.03	87.3%
#04	Canada	0.26	52.6%	#29	Italy	0.03	87.8%
#05	Indonesia	0.21	56.2%	#30	Egypt	0.03	88.3%
#06	Iran	0.19	59.6%	#31	Thailand	0.03	88.8%
#07	India	0.17	62.5%	#32	Netherlands	0.03	89.2%
#08	Saudi Arabia	0.13	64.9%	#33	Ukraine	0.03	89.6%
#09	Australia	0.13	67.1%	#34	Turkmenistan	0.03	90.1%
#10	Iraq	0.11	69.1%	#35	Poland	0.02	90.5%
#11	Brazil	0.10	70.9%	#36	Malaysia	0.02	90.9%
#12	Algeria	0.08	72.3%	#37	Vietnam	0.02	91.4%
#13	UAE	0.08	73.7%	#38	Taiwan	0.02	91.8%
#14	Nigeria	0.07	74.9%	#39	Spain	0.02	92.2%
#15	Japan	0.07	76.1%	#40	Angola	0.02	92.6%
#16	Venezuela	0.07	77.3%	#41	Colombia	0.02	92.9%
#17	South Korea	0.07	78.4%	#42	Turkey	0.02	93.2%
#18	South Africa	0.06	79.5%	#43	France	0.02	93.5%
#19	Kazakhstan	0.06	80.5%	#44	Singapore	0.02	93.8%
#20	Argentina	0.05	81.5%	#45	Mongolia	0.02	94.1%
#21	Oman	0.05	82.3%	#46	Libya	0.02	94.4%
#22	Norway	0.05	83.1%	#47	Azerbaijan	0.01	94.7%
#23	Qatar	0.04	83.9%	#48	Pakistan	0.01	94.9%
#24	Mexico	0.04	84.7%	#49	Philippines	0.01	95.1%
#25	Kuwait	0.04	85.4%	#50	Mozambique	0.01	95.3%
					Rest of the World	0.27	100%

Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Buildings – Brazil is #21

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 7 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	China	0.86	20.3%	#26	Belgium	0.03	85.2%
#02	USA	0.76	38.3%	#27	Turkmenistan	0.03	85.9%
#03	Russia	0.25	44.2%	#28	Algeria	0.03	86.6%
#04	India	0.23	49.6%	#29	Kazakhstan	0.03	87.2%
#05	Japan	0.17	53.7%	#30	Uzbekistan	0.02	87.7%
#06	Germany	0.14	57.1%	#31	Vietnam	0.02	88.3%
#07	Iran	0.14	60.4%	#32	Egypt	0.02	88.8%
#08	Canada	0.11	63.1%	#33	Bangladesh	0.02	89.2%
#09	UK	0.10	65.5%	#34	Czechia	0.02	89.6%
#10	France	0.10	67.7%	#35	Thailand	0.02	90.0%
#11	Italy	0.09	69.8%	#36	Ethiopia	0.02	90.3%
#12	Turkey	0.07	71.5%	#37	Romania	0.01	90.7%
#13	Poland	0.06	73.0%	#38	Switzerland	0.01	91.0%
#14	South Korea	0.06	74.5%	#39	Hungary	0.01	91.3%
#15	Indonesia	0.05	75.8%	#40	Oman	0.01	91.6%
#16	South Africa	0.05	76.8%	#41	Greece	0.01	91.9%
#17	Australia	0.04	77.9%	#42	Colombia	0.01	92.2%
#18	Nigeria	0.04	78.8%	#43	Philippines	0.01	92.5%
#19	Spain	0.04	79.7%	#44	Austria	0.01	92.7%
#20	Argentina	0.04	80.6%	#45	Myanmar	0.01	93.0%
#21	Brazil	0.04	81.4%	#46	Iraq	0.01	93.2%
#22	Mexico	0.03	82.2%	#47	Morocco	0.01	93.5%
#23	Pakistan	0.03	83.0%	#48	Ireland	0.01	93.7%
#24	Netherlands	0.03	83.8%	#49	Taiwan	0.01	93.9%
#25	Ukraine	0.03	84.5%	#50	Chile	0.01	94.1%
					Rest of the World	0.25	100%

Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Waste – Brazil is #4

Yearly CO_2e emissions – 50 most polluting countries

2019, in Gt CO_2e

Top 9 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	China	0.82	24.8%	#26	Canada	0.02	78.9%
#02	India	0.31	34.1%	#27	Morocco	0.02	79.6%
#03	Indonesia	0.17	39.3%	#28	Algeria	0.02	80.1%
#04	Brazil	0.16	44.2%	#29	Malaysia	0.02	80.7%
#05	USA	0.14	48.6%	#30	Cambodia	0.02	81.3%
#06	Russia	0.11	51.7%	#31	Germany	0.02	81.8%
#07	Bangladesh	0.10	54.7%	#32	Ethiopia	0.02	82.3%
#08	Thailand	0.09	57.5%	#33	Argentina	0.02	82.8%
#09	Vietnam	0.08	59.8%	#34	Italy	0.02	83.3%
#10	Mexico	0.07	62.1%	#35	Chile	0.01	83.8%
#11	Pakistan	0.06	63.9%	#36	Taiwan	0.01	84.2%
#12	Turkey	0.06	65.7%	#37	Iraq	0.01	84.7%
#13	Philippines	0.06	67.4%	#38	Sri Lanka	0.01	85.1%
#14	Nigeria	0.05	69.0%	#39	Australia	0.01	85.5%
#15	Myanmar	0.05	70.5%	#40	Peru	0.01	85.9%
#16	South Korea	0.03	71.4%	#41	Nepal	0.01	86.3%
#17	Japan	0.03	72.3%	#42	Tanzania	0.01	86.7%
#18	Saudi Arabia	0.03	73.2%	#43	Venezuela	0.01	87.1%
#19	Colombia	0.03	74.0%	#44	Sudan	0.01	87.5%
#20	South Africa	0.02	74.8%	#45	Finland	0.01	87.8%
#21	Egypt	0.02	75.6%	#46	UK	0.01	88.1%
#22	Iran	0.02	76.3%	#47	North Korea	0.01	88.4%
#23	France	0.02	77.0%	#48	Kuwait	0.01	88.7%
#24	Spain	0.02	77.6%	#49	Ukraine	0.01	89.0%
#25	Congo[1]	0.02	78.3%	#50	Uzbekistan	0.01	89.2%
					Rest of the World	0.35	100%

1. Democratic Republic of Congo
Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Maritime – Brazil is #43

Yearly CO_2e emissions – 50 most polluting countries

2019, in Mt CO_2e

Top 7 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	Panama	144.63	15.2%	#26	Turkey	5.42	92.0%
#02	Liberia	103.15	26.0%	#27	India	4.68	92.5%
#03	Marshall Islands	90.37	35.5%	#28	Philippines	4.30	92.9%
#04	Hong Kong	84.59	44.3%	#29	Malaysia	4.16	93.4%
#05	Singapore	62.69	50.9%	#30	Taiwan	3.66	93.8%
#06	Malta	55.50	56.7%	#31	Spain	3.63	94.1%
#07	Japan	54.71	62.5%	#32	Finland	3.60	94.5%
#08	Bahamas	43.88	67.1%	#33	Cayman Islands	3.53	94.9%
#09	China	35.67	70.8%	#34	Sweden	3.19	95.2%
#10	Greece	21.94	73.1%	#35	Thailand	2.79	95.5%
#11	Denmark	20.17	75.2%	#36	Saudi Arabia	2.76	95.8%
#12	Cyprus	18.37	77.2%	#37	Belgium	2.61	96.1%
#13	Italy	15.52	78.8%	#38	Vietnam	2.59	96.3%
#14	Norway	14.78	80.3%	#39	Canada	2.50	96.6%
#15	Portugal	14.54	81.9%	#40	Gibraltar	2.24	96.8%
#16	Netherlands	11.43	83.1%	#41	Iran	1.95	97.0%
#17	Indonesia	11.39	84.3%	#42	Belize	1.89	97.2%
#18	Bermuda	11.14	85.4%	#43	Brazil	1.57	97.4%
#19	UK	9.24	86.4%	#44	St. Vincent	1.28	97.5%
#20	Antigua/Barbuda	9.09	87.3%	#45	Barbados	1.27	97.7%
#21	USA	9.05	88.3%	#46	Chile	1.25	97.8%
#22	Isle of Man	8.53	89.2%	#47	Kuwait	1.16	97.9%
#23	Germany	8.18	90.0%	#48	Croatia	1.15	98.1%
#24	Russia	7.59	90.8%	#49	Sierra Leone	0.91	98.1%
#25	France	5.56	91.4%	#50	Faroe Islands	0.87	98.2%
					Rest of the World	16.81	100%

Source: Climate TRACE; BCG analysis

World's 50 largest GHG emitters in Extraction (Mining) – Brazil is #4

Yearly CO_2e emissions – 50 most polluting countries

2019, in Mt CO_2e

Top 6 ~60%

RANK			Cumulative share (%)	RANK			Cumulative share (%)
#01	China	9.20	16.7%	#26	Philippines	0.28	92.2%
#02	Australia	8.42	32.0%	#27	Saudi Arabia	0.23	92.7%
#03	Chile	6.87	44.5%	#28	Laos	0.20	93.0%
#04	Brazil	4.20	52.1%	#29	France	0.20	93.4%
#05	USA	3.56	58.6%	#30	Spain	0.18	93.7%
#06	India	2.24	62.7%	#31	UK	0.15	94.0%
#07	Peru	2.18	66.6%	#32	Myanmar	0.14	94.2%
#08	Russia	2.14	70.5%	#33	Italy	0.13	94.5%
#09	Congo[1]	1.63	73.5%	#34	Japan	0.13	94.7%
#10	Canada	1.38	76.0%	#35	Argentina	0.12	94.9%
#11	Indonesia	1.26	78.3%	#36	Mauritania	0.12	95.1%
#12	Mexico	1.11	80.3%	#37	Uzbekistan	0.12	95.4%
#13	Zambia	0.75	81.7%	#38	UAE	0.11	95.6%
#14	Kazakhstan	0.66	82.9%	#39	Thailand	0.11	95.8%
#15	Turkey	0.62	84.0%	#40	Portugal	0.11	96.0%
#16	Iran	0.60	85.1%	#41	Armenia	0.10	96.1%
#17	Poland	0.56	86.1%	#42	Pakistan	0.09	96.3%
#18	Ukraine	0.48	87.0%	#43	Algeria	0.09	96.5%
#19	Mongolia	0.43	87.8%	#44	South Korea	0.09	96.6%
#20	Sweden	0.42	88.5%	#45	Egypt	0.09	96.8%
#21	Vietnam	0.42	89.3%	#46	North Korea	0.08	96.9%
#22	Guinea	0.40	90.0%	#47	Bulgaria	0.08	97.1%
#23	South Africa	0.36	90.7%	#48	Bangladesh	0.08	97.2%
#24	Malaysia	0.30	91.2%	#49	Austria	0.07	97.3%
#25	Germany	0.28	91.7%	#50	Serbia	0.07	97.5%
					Rest of the World	1.40	100%

1. Democratic Republic of Congo
Source: Climate TRACE; BCG analysis

Brazil emits more GHG in AFOLU than the entire World in activities such as Cement, Oil Refining or Aviation

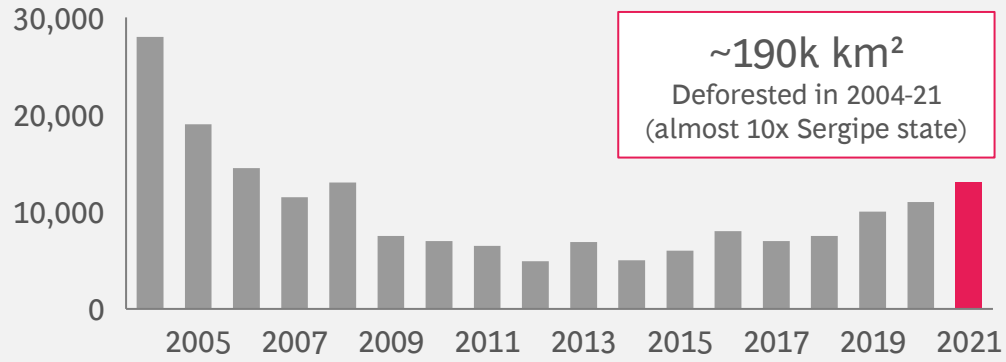
AFOLU[1] (Agriculture, Forestry and Other Land Use) in Brazil	Cement Production WORLDWIDE	Oil Refining WORLDWIDE	Aviation WORLDWIDE	Shipping WORLDWIDE
1.7 Gt CO_2e/yr	**1.5** Gt CO_2e/yr	**1.3** Gt CO_2e/yr	**1.0** Gt CO_2e/yr	**1.0** Gt CO_2e/yr

1. GHG emissions from forest clearing and fires in forests, shrublands, and savannas; emissions are gross estimates and do not include carbon sink. It includes both legal and illegal human activities, as well as fires from natural causes. Note: Numbers from 2019; Worldwide emissions also include Brazil. Source: Climate TRACE; BCG analysis

Deforestation & environmental funding reduction have raised questions about Brazil's commitment to Climate

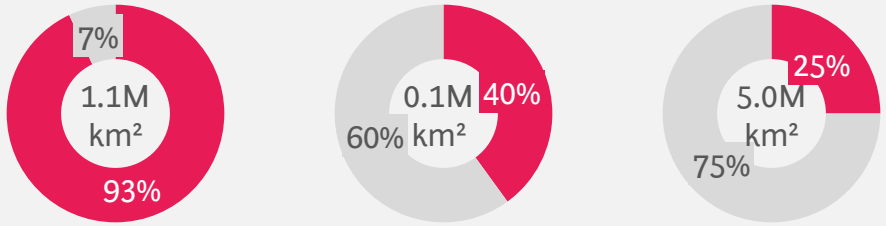
Amazon deforestation highest since 2006

Annual rate in square kilometer



Cumulative deforestation by Brazilian Biome

Percentage of total biome area (shown in square kilometer on center)



Total deforested area by 2031 (versus original area)

Brazil: Amazon sees worst deforestation levels in 15 years

BBC, 19Nov21

Federal Government cuts R$ 35 million from the Ministry of the Environment budget for 2022

The president's veto on the budget approved by Congress mainly reduced funds for preventing and fighting fires

O Eco, 25Jan22

Jump in deforestation of world's most biodiverse savanna alarms Brazilian scientists

Deforestation last year rose to the highest level since 2015 in Brazil's Cerrado, prompting scientists to raise alarm over the state of the world's most species-rich savanna, a major carbon sink that helps to stave off climate change.

Reuters, 3Jan22

Brazil has cut 93% of funding for climate change research

BBC, 3Nov21

Source: BBC; Instituto Brasileiro de Florestas; Observatório Pantanal; Reuters, Statista; press search

Thank you

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Brazil Climate Summit.