Scaling Biochar in North America

State of the Industry and Opportunities for Growth

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Program Director

United States Biochar Initiative

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United States Biochar Initiative

- 501 (c)(3) non-profit dedicated to increasing production and use of biochar in North America
- Focus Areas:
  - Biochar market development
  - Biochar standards development
  - Technical support
  - Education and outreach
  - Annual conference
  - Carbon Dioxide Removal advocacy

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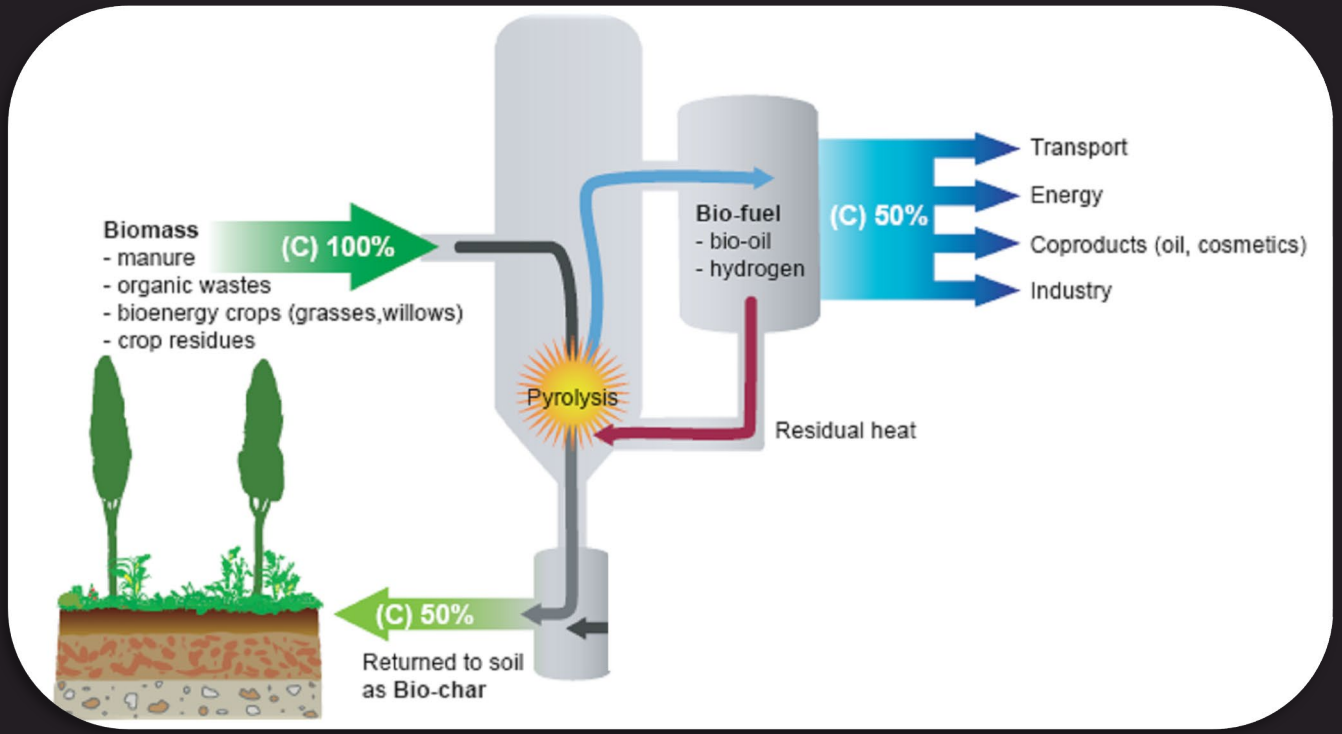
Biochar: Material and CDR technology



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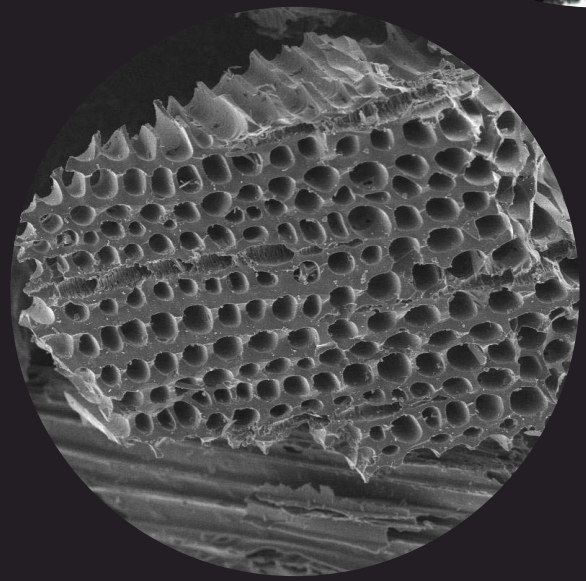
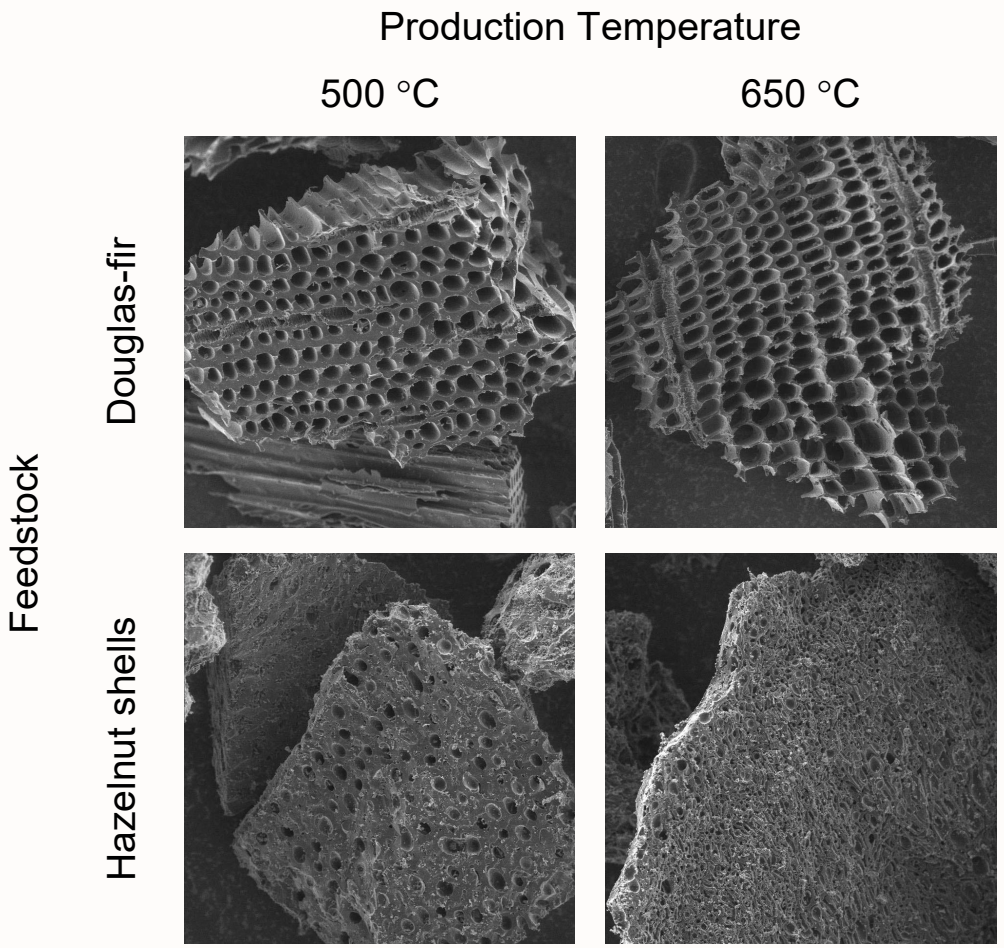
Biochar: A Physical Material

- **Granular black carbon, like charcoal**
- **Chemical structure is resistant to decay, with majority of C stable for 1,000+ years**
- **Properties depend on feedstock and production conditions**
- **Has multiple beneficial end uses:**
  - **Soil health amendment**
  - **Ingredient in biochar-enhanced fertilizers**
  - **Potting soil media to replace peat**
  - **Environmental remediation and restoration**
  - **Media for water filtration**
  - **Additive to materials including concrete**

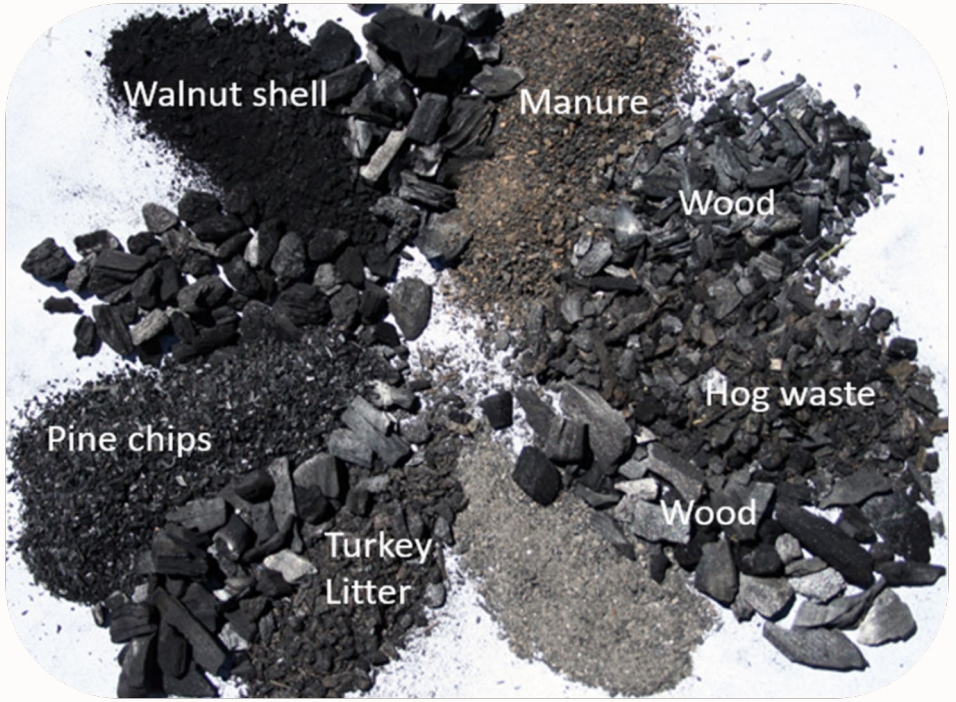


Biochar Material Properties



Feedstock and production process affect properties

- Different end-uses for different biochars
- Potential to create engineered, “designer biochars”



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Biochar End - Uses

Agriculture / Soil

- ↑ Crop yield
- ↑ Soil water holding
- ↑ Soil carbon
- ↑ Soil health
- ↓ Fertilizer Needs
- ↓ GHG Pollutants

Horticulture

- ↑ Plant health
- ↑ Plant growth
- ↓ Fertilizer needs
- ↓ Peat / Perlite
- ↓ Embodied carbon

Materials

- ↑ Performance
- ↓ Cement needs
- ↓ Embodied carbon

Environmental

- ↑ Plant growth
- ↑ Restoration rate
- ↓ Soil & water pollutants
- ↓ Odor management

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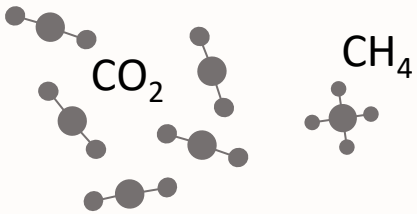
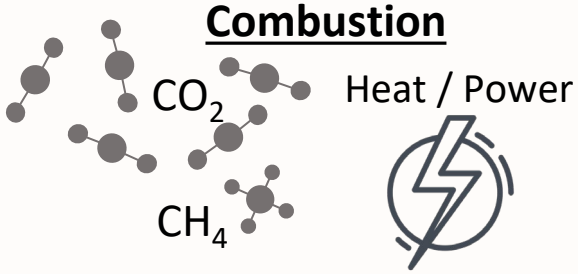
CDR Approach: Waste Biomass to Biochar

Typical Management

Natural Decomposition



Combustion

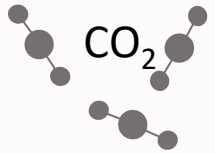


90%+ carbon equivalent emitted

Biochar Approach

Pyrolysis / Gasification

~20-25% biomass -> biochar
~40-50% carbon -> biochar
Remainder -> pyrolysis gas



Heat / Power

Biochar

Biochar is carbon removal to better manage waste biomass including:

- Forestry residuals
- Agricultural wastes
- Manure and biosolids
- Construction debris

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Biochar in CDR Methodologies

- **Four existing methodologies**
- **Underlying approach:**
  - **Credits depend on biochar properties**
    - **Range from ~1 to ~3 mt CO_2 / mt biochar**
  - **Credits deduct emissions from feedstock sourcing, production, and biochar shipping**
  - **Alternate feedstock fate assumed to be combustion / degradation to CO_2 (not CH_4)**
- **Not Considered in methodologies:**
  - **Heat / electricity / fuel production**
  - **Avoided feedstock methane emissions**
  - **End use benefits such as reduced fertilizer and replacement of high carbon materials**

CLIMATE ACTION RESERVE

CERTIFIED BIOCHAR EBC EUROPEAN BIOCHAR CERTIFICATE

Verified Carbon Standard

puro · earth

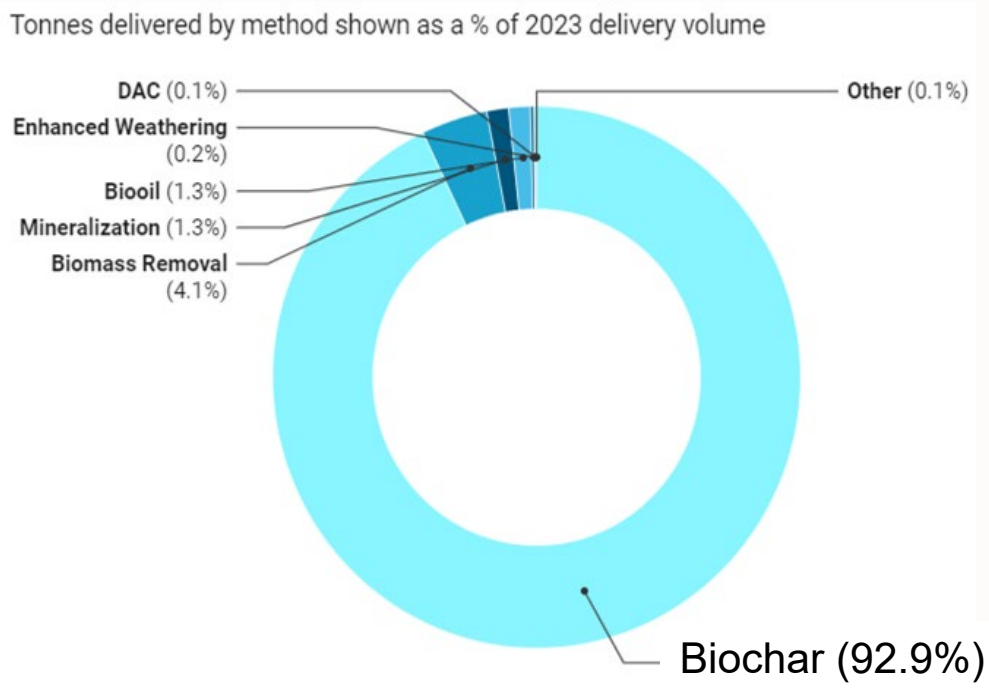
Key Methodology Requirements

- **Feedstock sustainability:**
  - **Waste only: standard practice must be combustion or decomposition**
  - **Sustainable sourcing requirements (e.g., SFI, FSC) are included in some methodologies**
- **Additionality:**
  - **Production must be result of carbon finance**
  - **Most methodologies exclude facilities operational prior to credit availability**
- **MRV: Monitoring, Reporting, Verification:**
  - **Guarantees that end-users do not combust**
  - **Regular biochar material analysis**
  - **Facility audits**

Current Role of Biochar in CDR Ecosystem

Readiness	Proven and shovel ready; TRL 7-9
Current Credit Pricing	$100 - $200 per mt CO_2
Scalability	Decentralized scaling in proximity to waste biomass
Global Potential	>2 gigaton per year
Energy Competition	Process produces energy; No renewable electricity competition
Permanence	Industrial biochar: >1,000 years Artisanal biochar: 100-1,000 years
Co-Benefits	Many, across supply-chain types

~93% of delivered durable CDR in 2023



cdr.fyi 2023 Annual Report

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Decoupled Credits

Majority of biochar carbon credits are decoupled form physical biochar

Carbon Removal Credits → $100-$200 / mt CO_2

Physical Biochar → Variable

$100-$400 / mt biochar

$200-$600 / mt biochar

CDR credits account for emissions from feedstock sourcing, biochar production, and biochar shipping

↓

Physical biochar is a zero carbon material

CDR Credit Buyers:

- Primarily technology companies
- Prioritize credit quality over price

Biochar Buyers:

- Used in multiple value chain types, primarily agricultural and industrial
- Currently targeting lower cost abatement

Biochar Business Models

Most biochar producers have at least two revenue streams

Feedstock
- Typically a cost; up to $75/ton
- Can generate revenue from difficult feedstocks:
  - Manures
  - Ag processing waste
  - Wastewater biosolids
  - Urban green waste
  - Municipal wastes
  - Construction debris

Pyrolysis / Gasification
4-5 mt feedstock/mt biochar

Pygas
Multiple uses / values
- Heat
- Electricity
- Fuels
- Chemicals
- Hydrogen

Carbon Credits
~$100-$400/mt biochar

Biochar
~$200-$600/mt biochar

Biochar Production: Mobile to Industrial Scale

Carbonator 6050
tigercat.com

ARTIchar
artichar.com

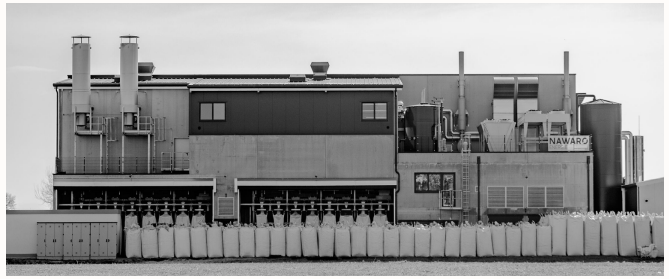
Pyreg 500-6000
Pyreg.de

ICM Inc
icminc.com

CharBoss
airburners.com

Biomacon
Biomacon.com

Airex
Airex-energy.com



Syncraft
Syncraft.at

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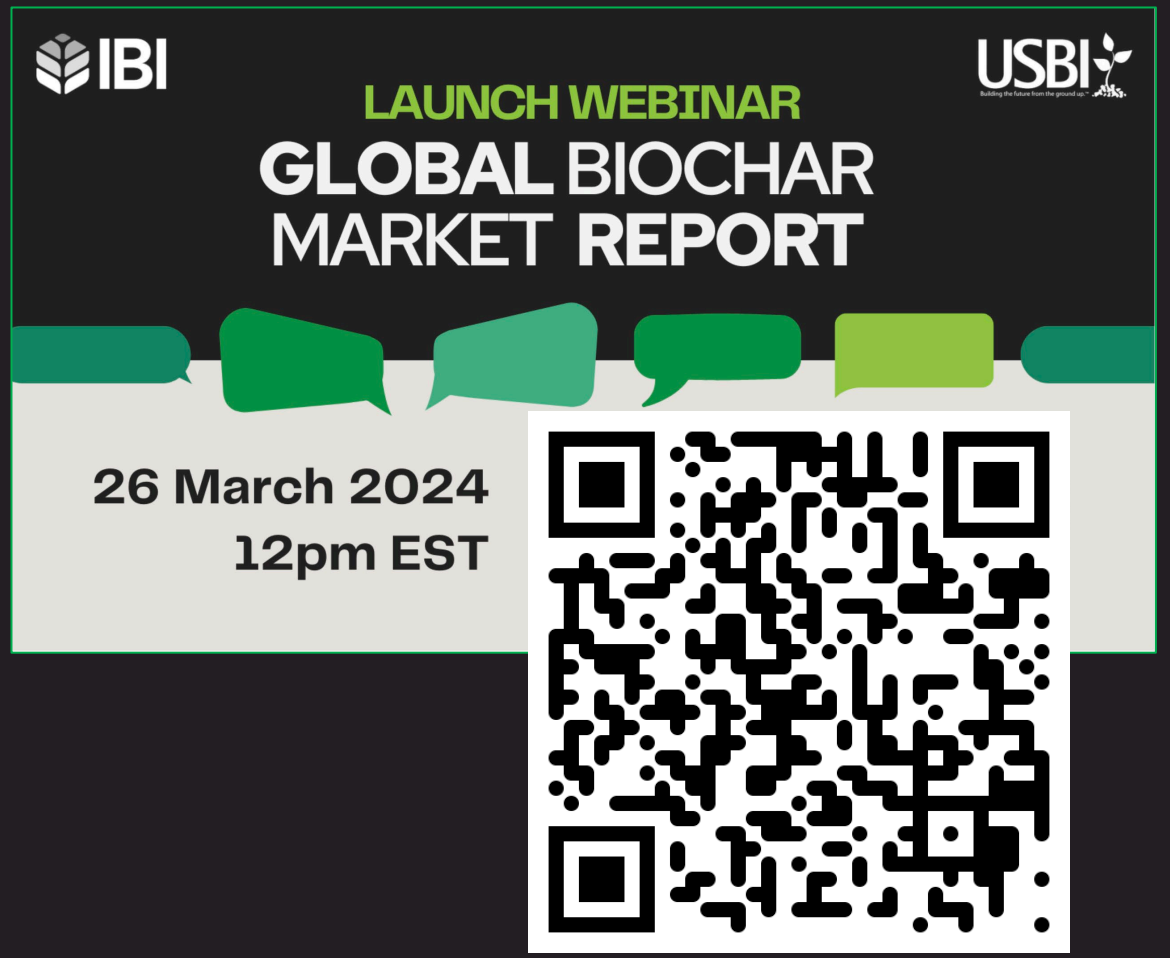
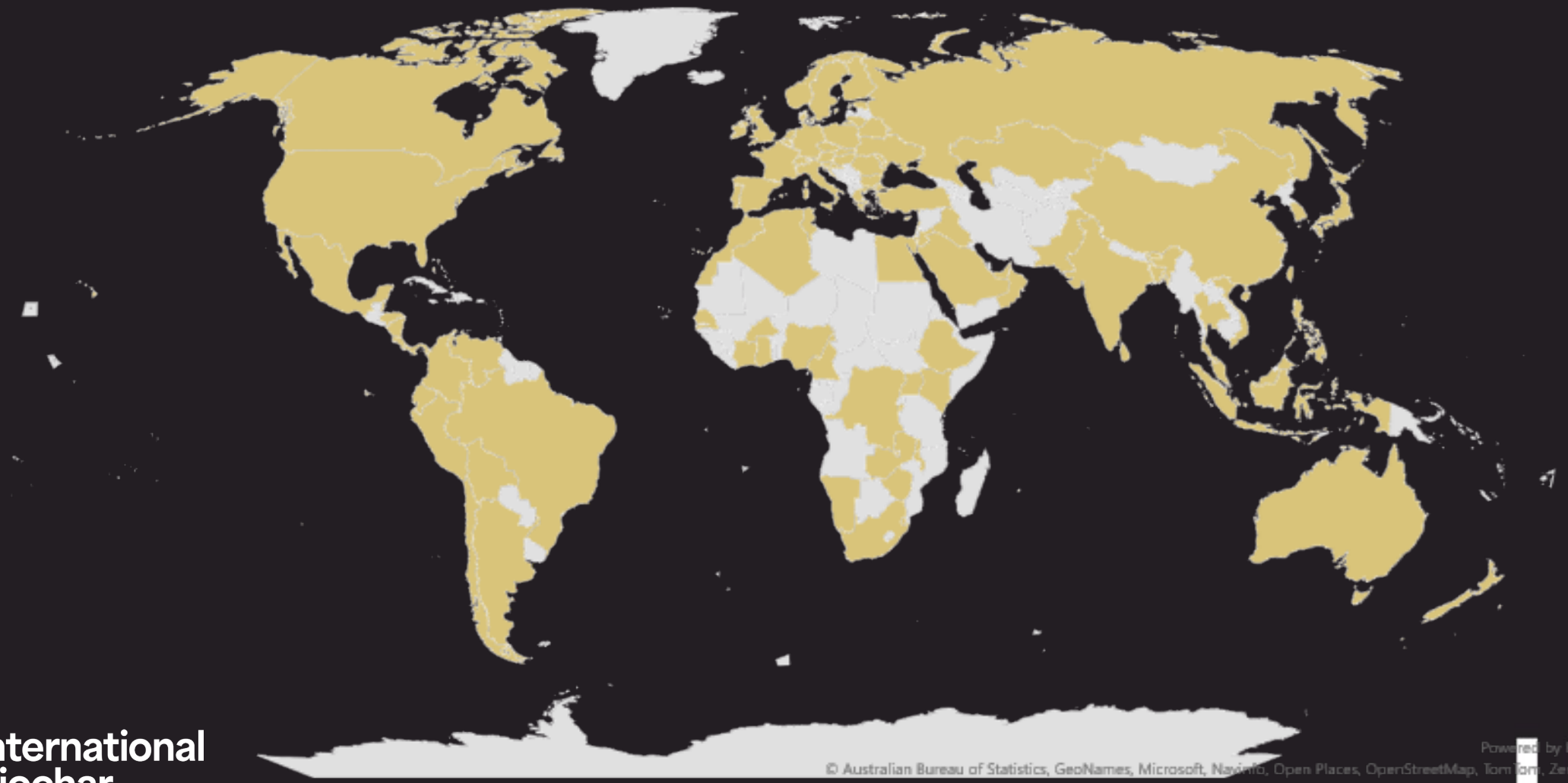
Status of the Industry: Global Survey

Interactive Global Survey:

- Joint IBI / USBI project
- Web-based survey
- Collected November 2023
- Data anonymized and regionalized by 3rd party market research firm
- Final Report release next week
  - Available on IBI and USBI websites



Global Survey: 101 Countries Represented



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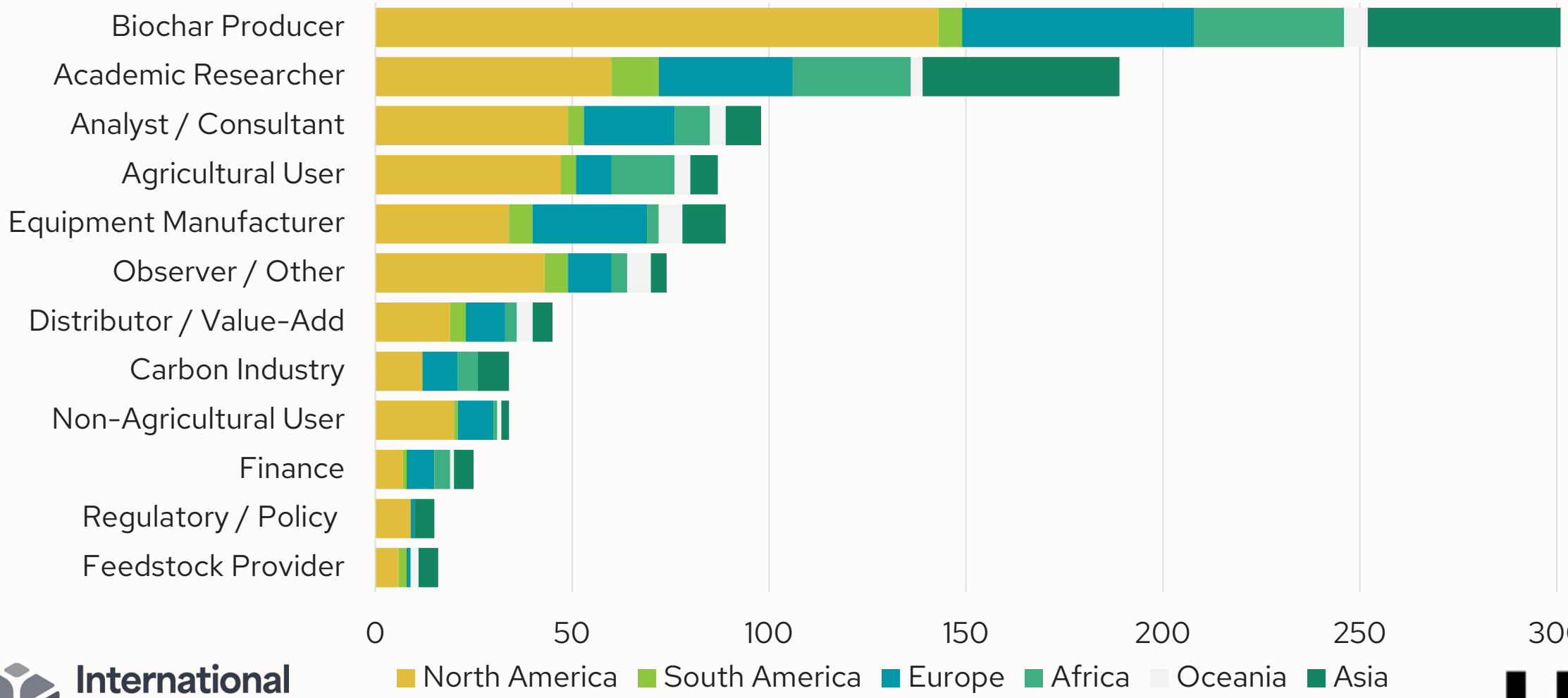
Global Survey: Respondents



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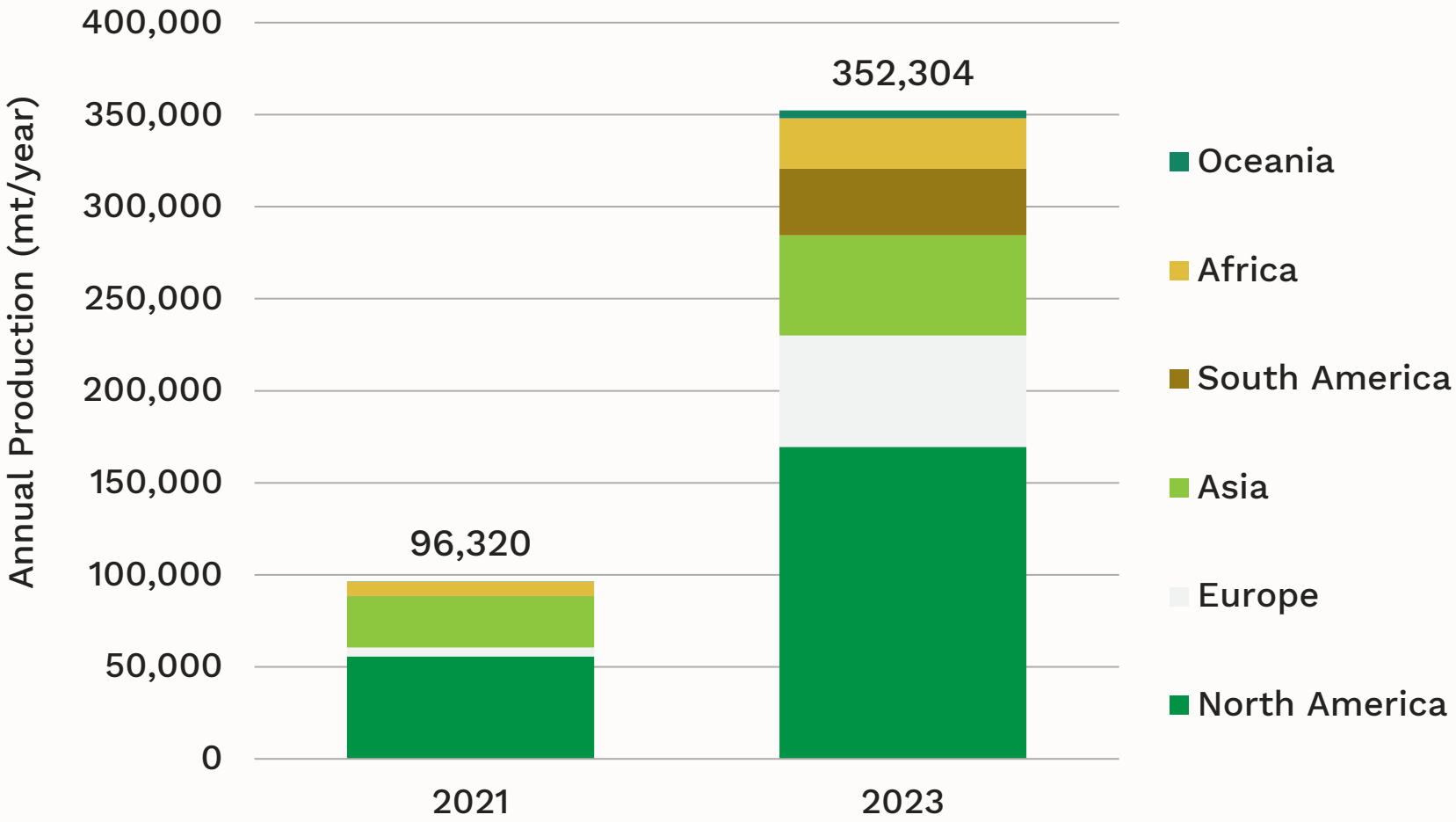
Global Survey: Key Takeaways

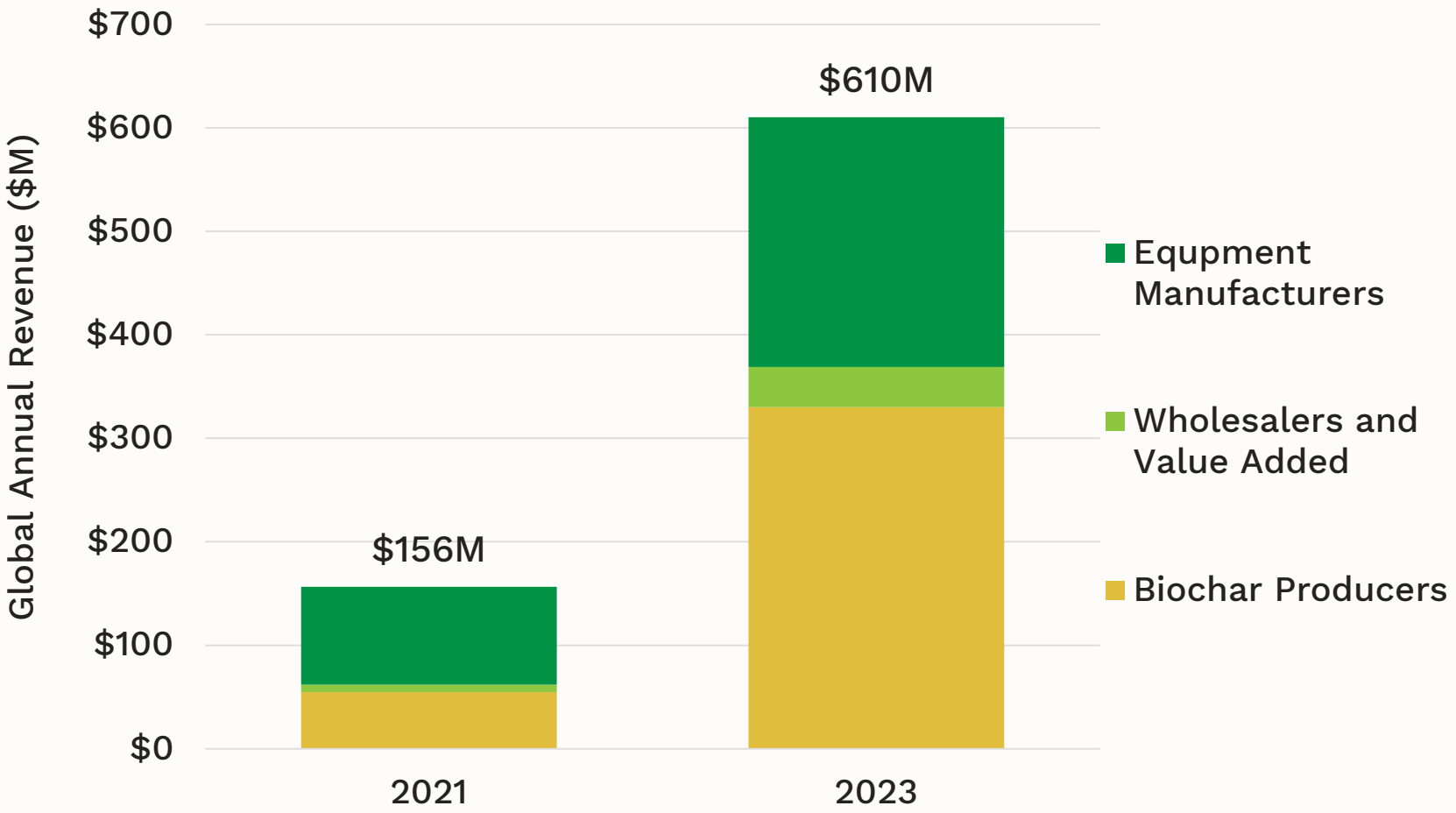
1. Biochar leads the way in delivering durable CDR with global production of at least **350,000 mt of biochar, equivalent to 400,000-800,000 mt CO_2**
2. CDR markets for biochar are thriving, but **majority of biochar producers do not generate revenue from CDR credits**
3. Market for physical biochar are growing, but **developing high value, high volume end-use markets is a key obstacle to growth.**
4. Biochar producers use **a range of production types and business models.**
5. Respondents expect **biochar organizations to focus on:**
    - Developing end-use markets for biochar
    - Advocating for biochar in CDR space and in government policy
    - Improving access to capital and grant funding

Global Survey: Production Growth



- Rapid production growth with 91% CAGR from 2021 to 2023
- CDR of 400,000 - 800,000 mt
- High anticipated growth
- Path to gigaton by 2040

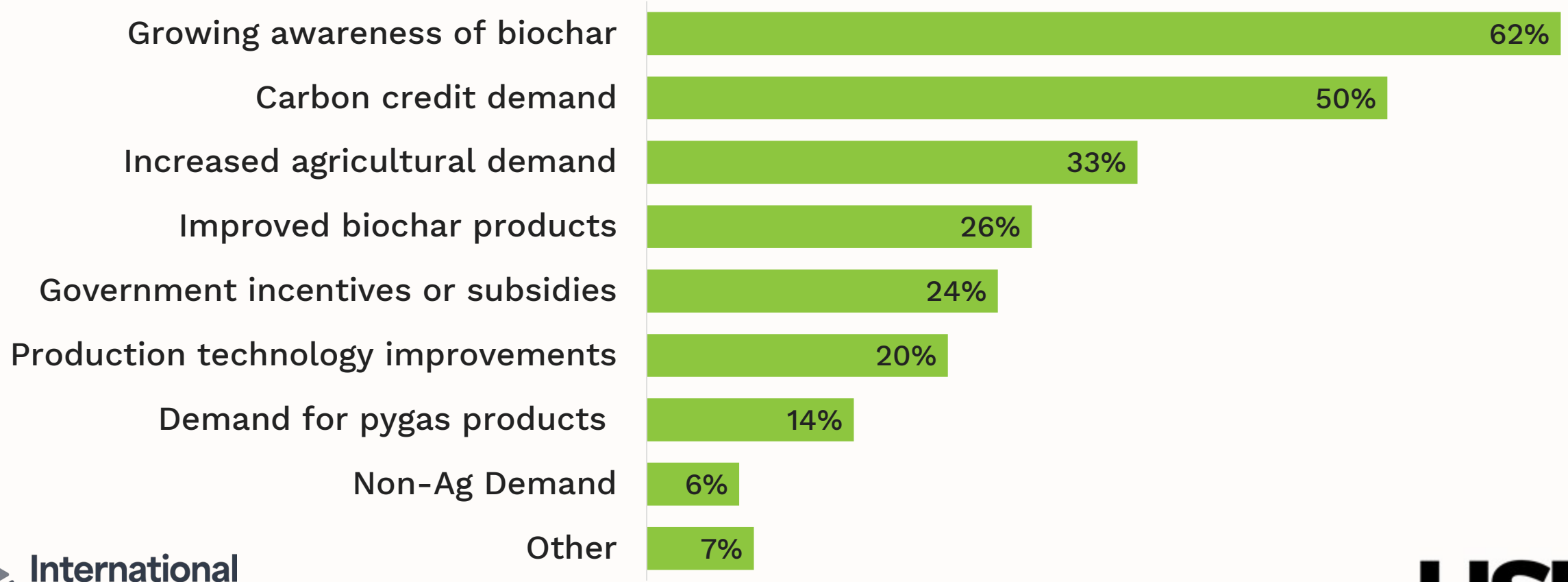
Global Survey: Economic Growth



- Rapid growth 2021 to 2023
- High anticipated growth
- Data represent early stage industry:
  - High equipment revenue
  - Low wholesale & value-added revenue

Global Survey: Key Growth Drivers

What are the key factors driving growth of the industry? (Select top 3)



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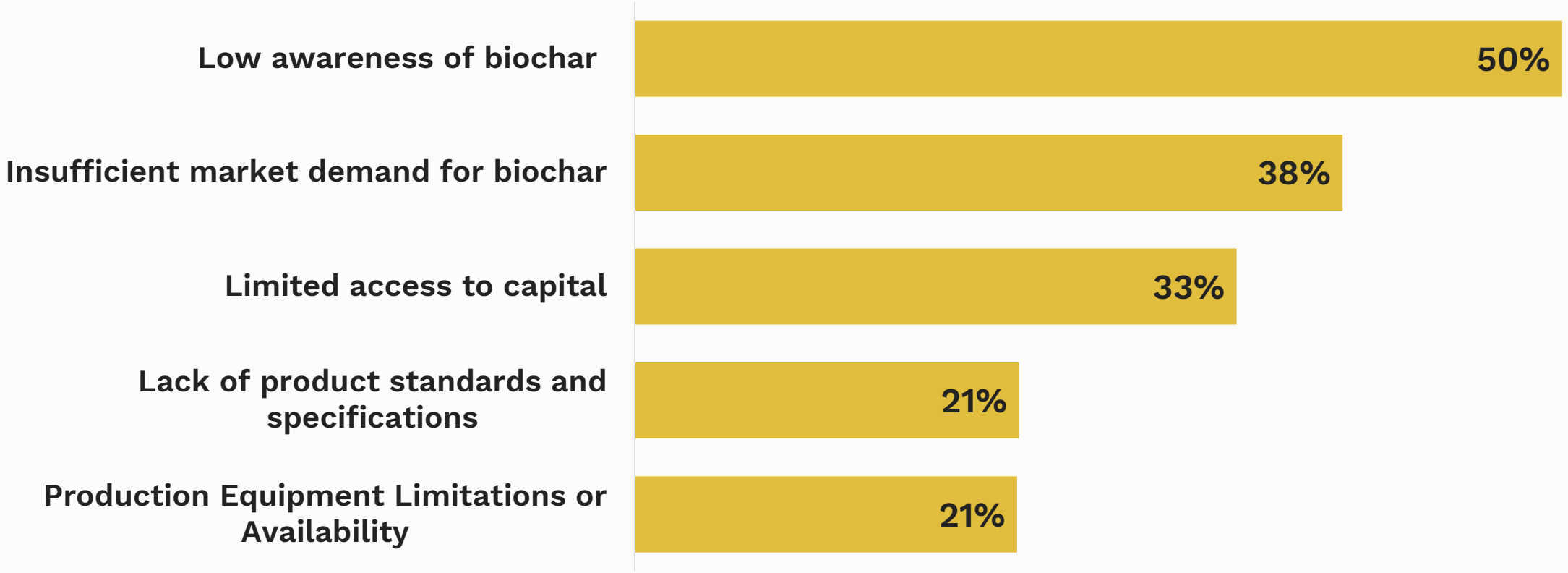
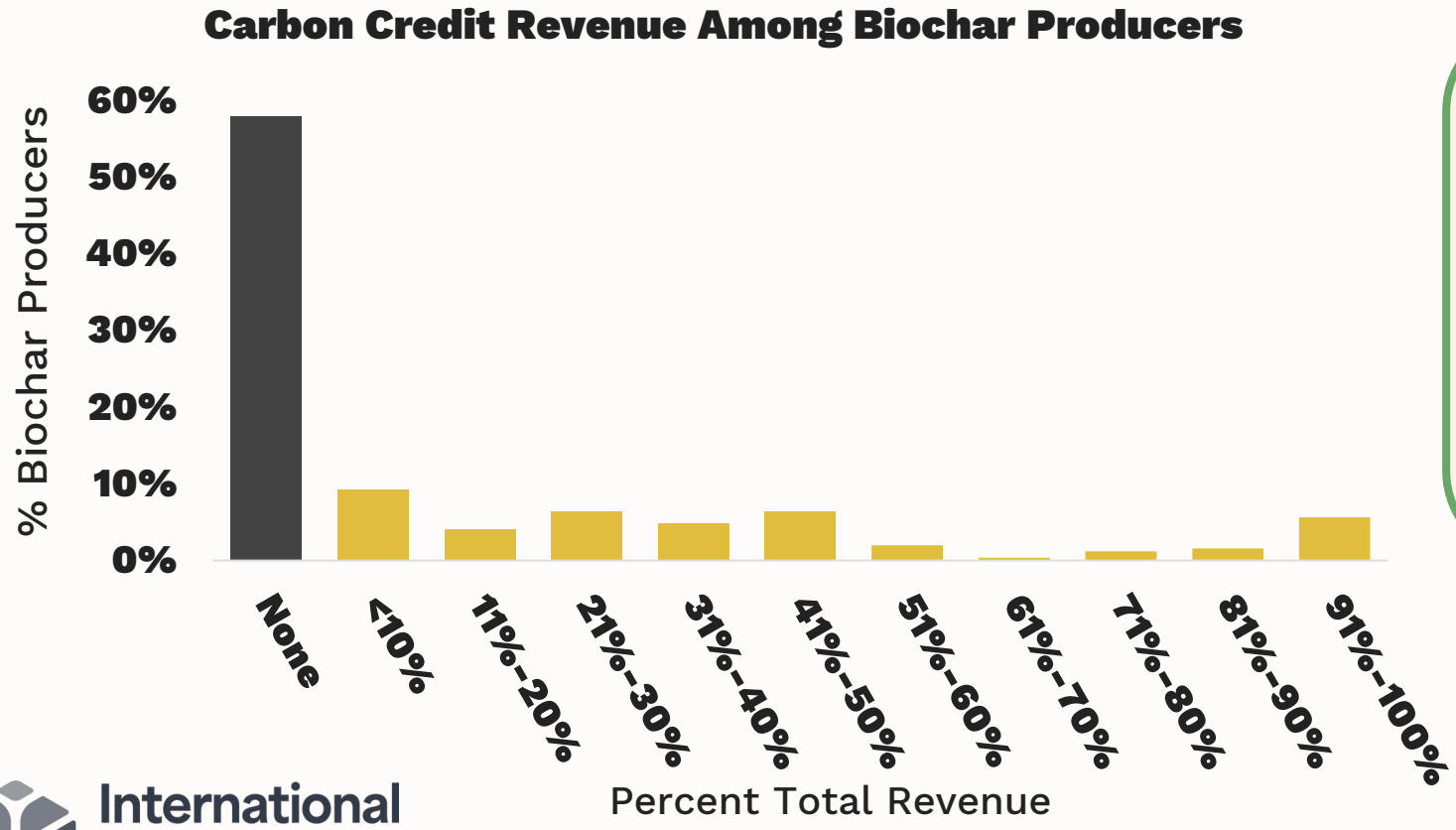
Global Survey: Key Obstacles to Further Growth

What are primary challenges or obstacles for the industry? (Select top 3)



Global Survey: Carbon Markets Leading the Way

#2 growth factor, but most producers do not generate credits



- More than half of global production not associated with credit sales
- Potential obstacles:
  - Methodology additionality
  - High certification / transaction costs
  - Small scale production

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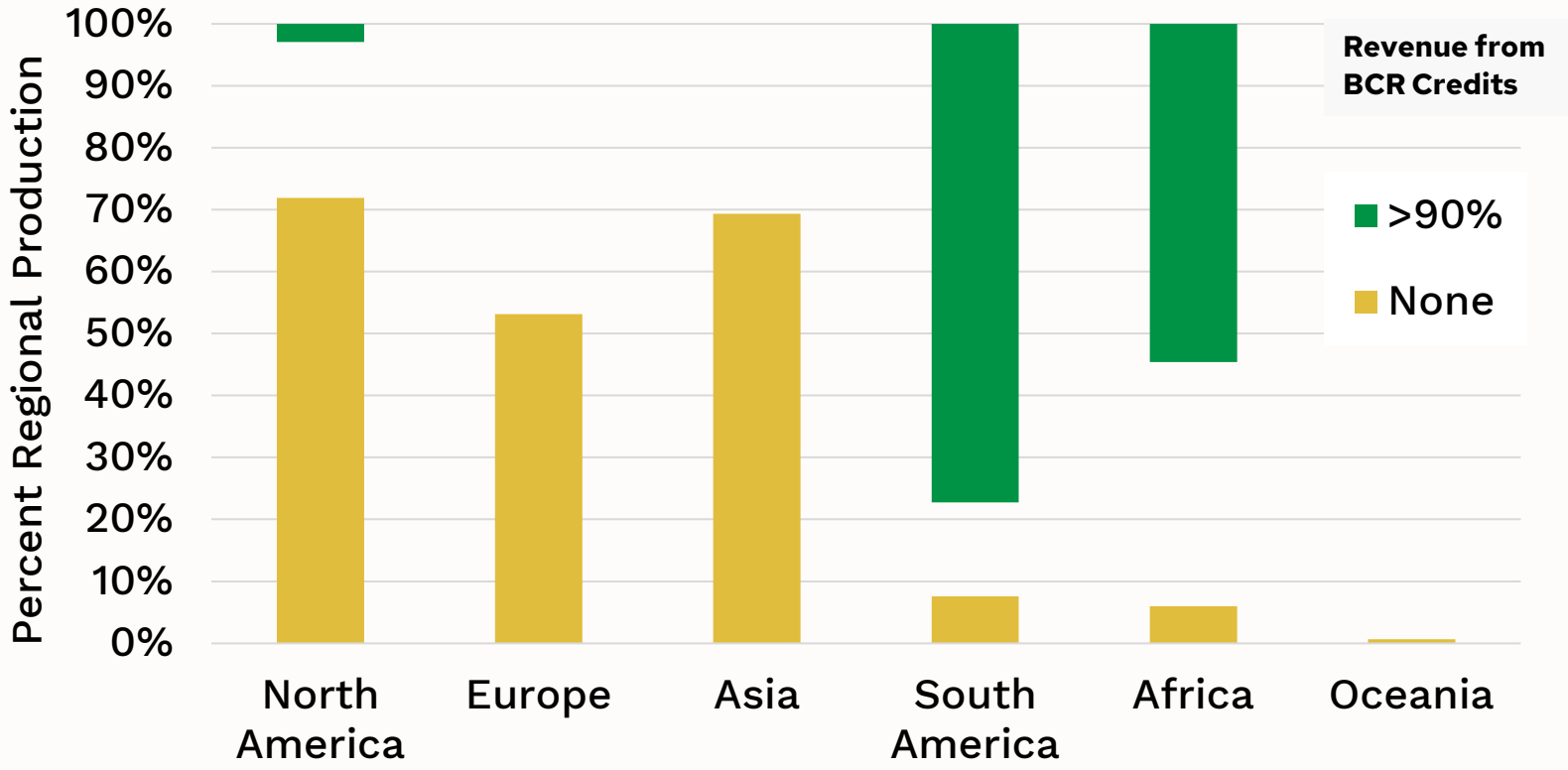
Global Survey: BCR Revenue Around the World

Major differences in carbon market revenue between regions



- Very high CDR credit revenue in Africa and South America
  - Low labor costs may be a factor
- Low revenue in regions with most biochar production, potentially due to additionality requirements

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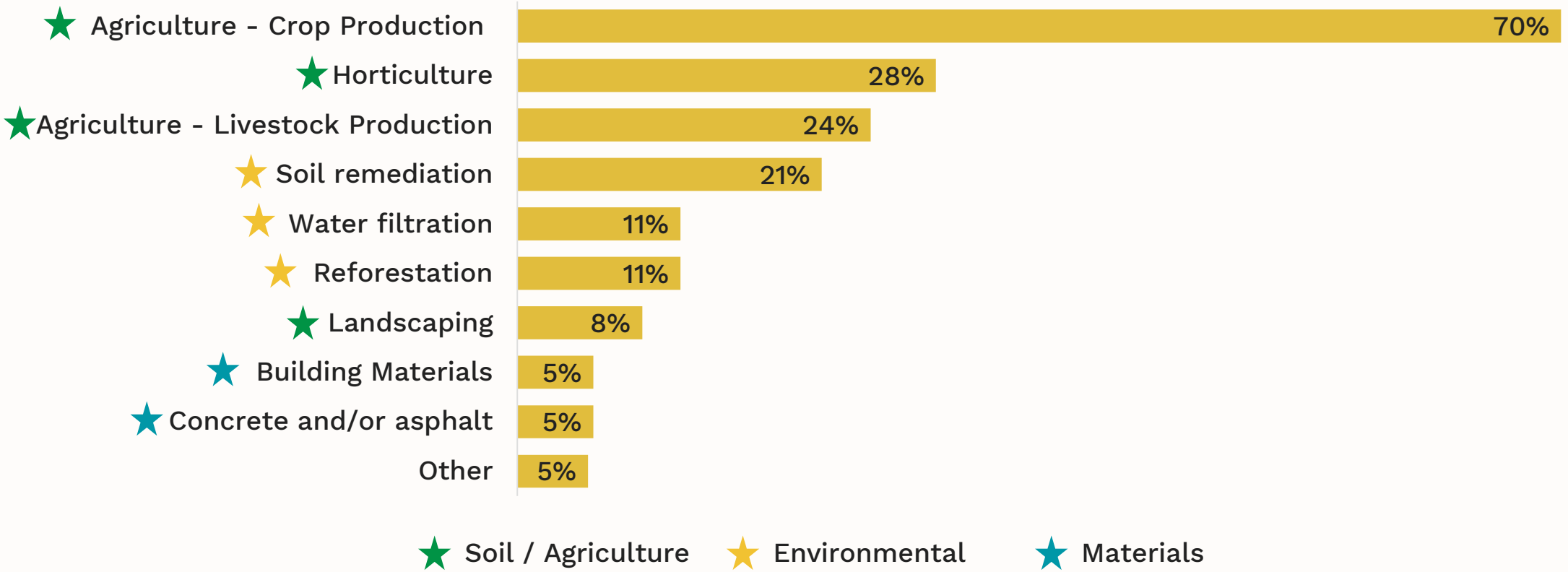
Global Survey: Soil / Ag Is Leading Market

Top end-use markets for physical biochar among biochar producers



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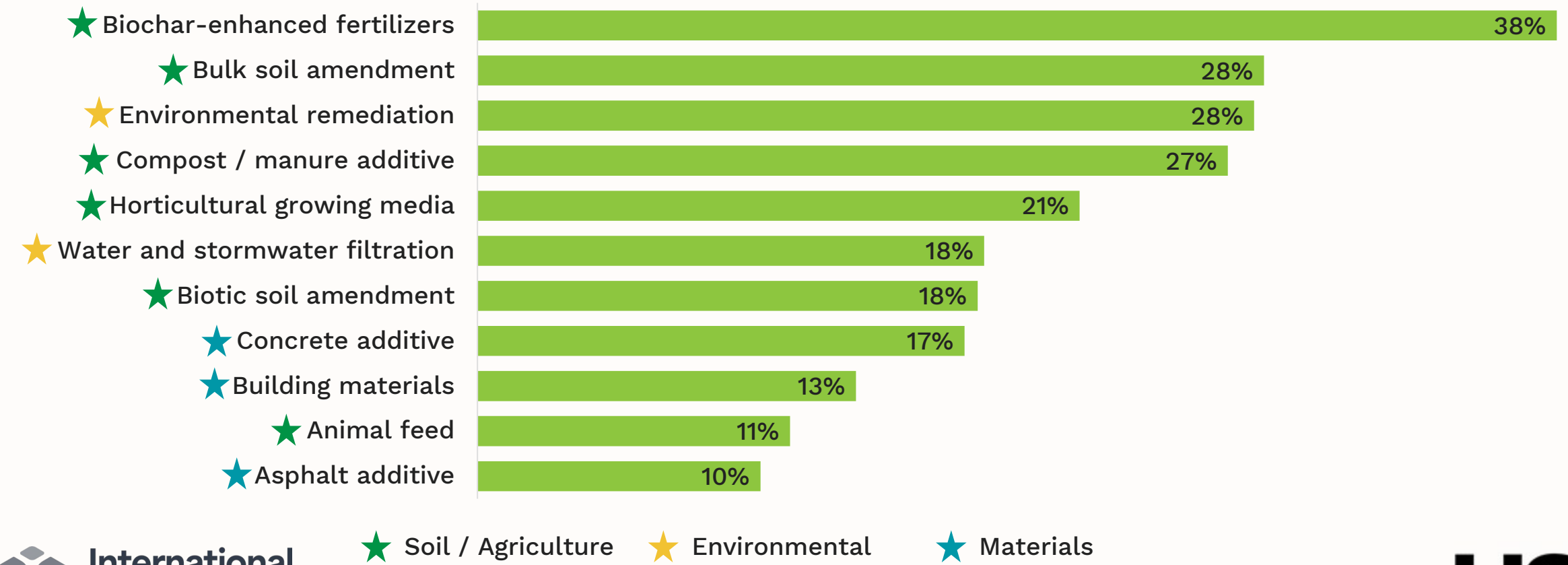
Global Survey: Developing Markets

Priorities for End-Use Market Development



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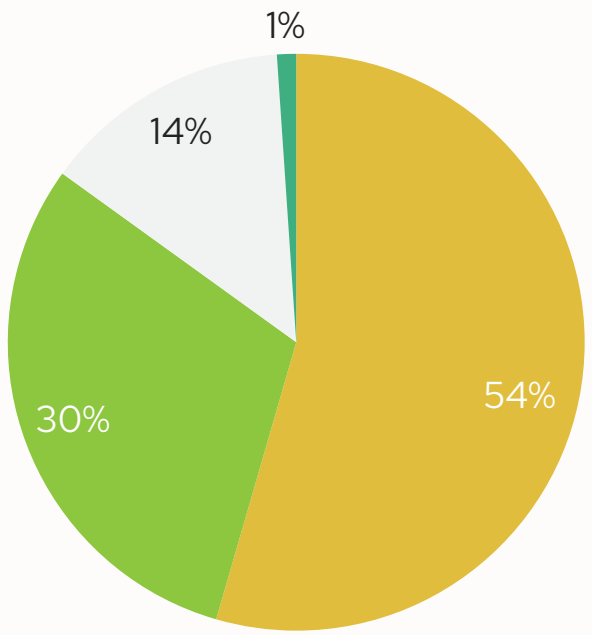
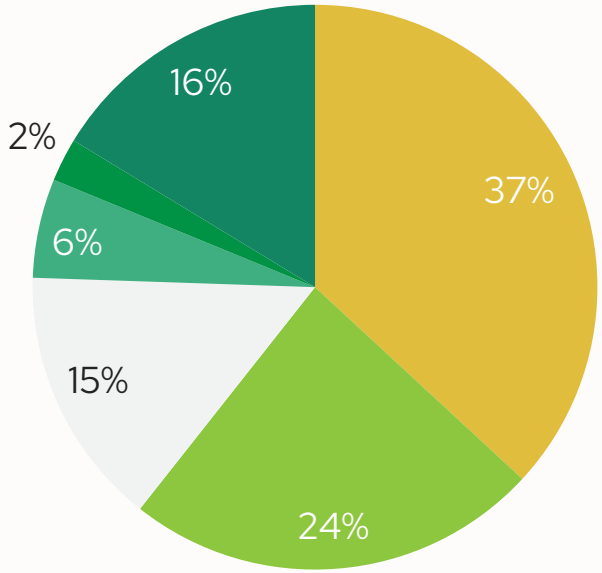
Global Survey: High Diversity in Production

Biochar production systems can be customized to local circumstances



- Built our own production equipment
- Bought a turnkey system directly from amanufacturer
- Bought components from manufacturers, then integrated them.
- Bought a turnkey system from a local distributor



- Stationary system, continuous auger or kiln
- Portable kiln
- Stationary system, batch reactor
- Mobile carbonizers
- High carbon fly ash extraction
- Other

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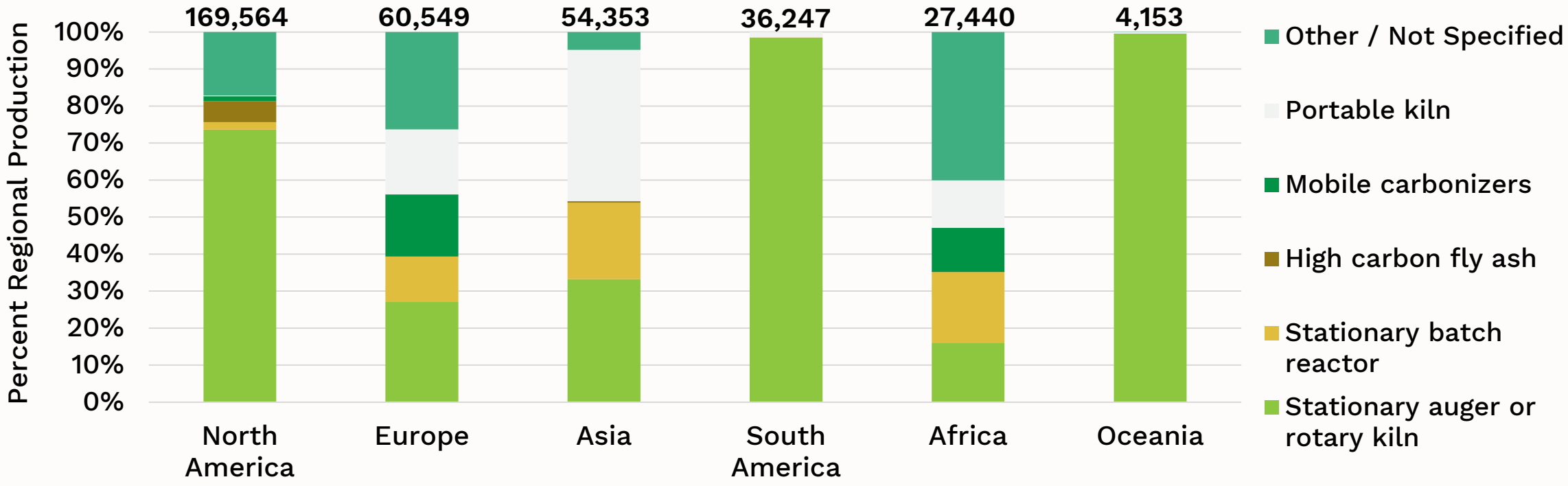
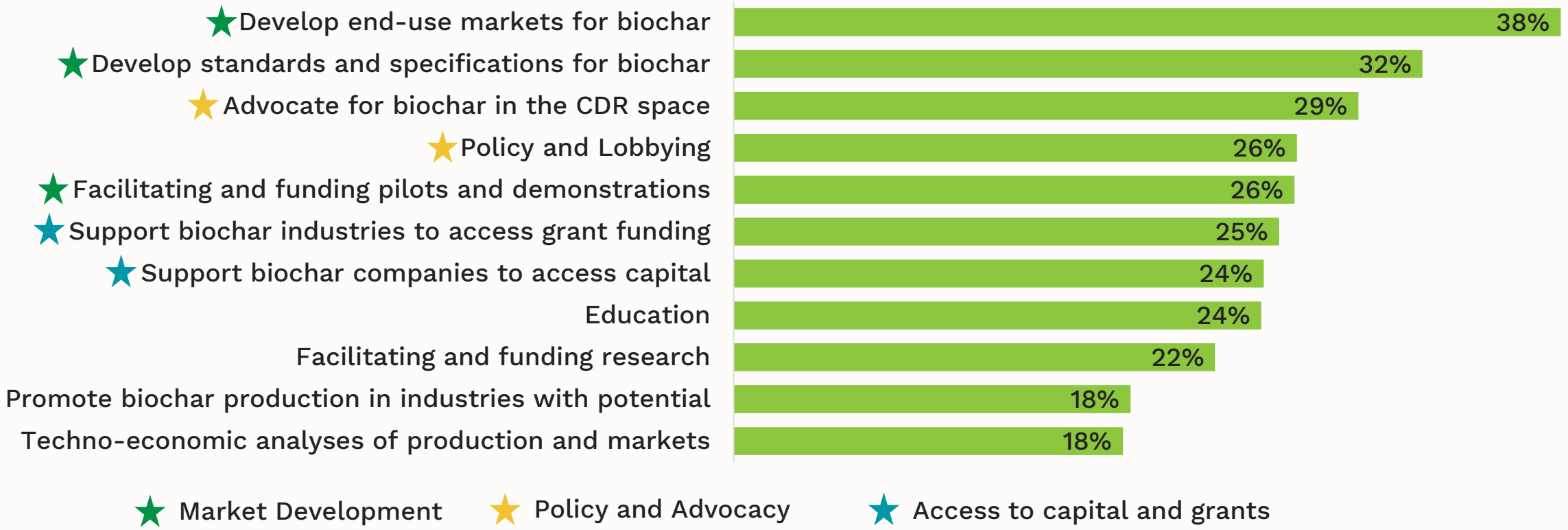
Global Survey: Production Around the World

Regional differences in biochar production technologies



Global Survey: Role of Biochar Associations

Strategic focus areas for biochar associations according to respondents



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Challenges and Opportunities

Focus on revenue streams

Feedstock
- Target feedstocks with high disposal costs to generate revenue or reduce cost

Pyrolysis / Gasification

Pygas
- Develop alternative pygas end uses

Carbon Credits
- Improve standing in VCM
- Inset biochar to reduce value-chain emissions

Biochar
- Increase soil demand
- Develop products for other end-uses
- Develop standards

Feedstock: Focus on True Waste Feedstocks

Reduce disposal costs or generate tipping fee revenue by processing hard to manage biomass

Construction & Demolition

Green waste - Landfill

USBI Approach:

- **Increase awareness among industries with waste issues**
- **Provide technical assistance**

Forestry slash

Example: Wastewater Biosolids

- Traditionally land applied to agricultural soils
- PFAS chemicals have led to landfilling being most common disposal.

Biochar is a lower-cost solution:

- Well-designed production destroys PFAS
- Reduces total mass and shipping / disposal costs
- Biochar use in materials like concrete

Carbon: Advocate for Biochar in CDR Space

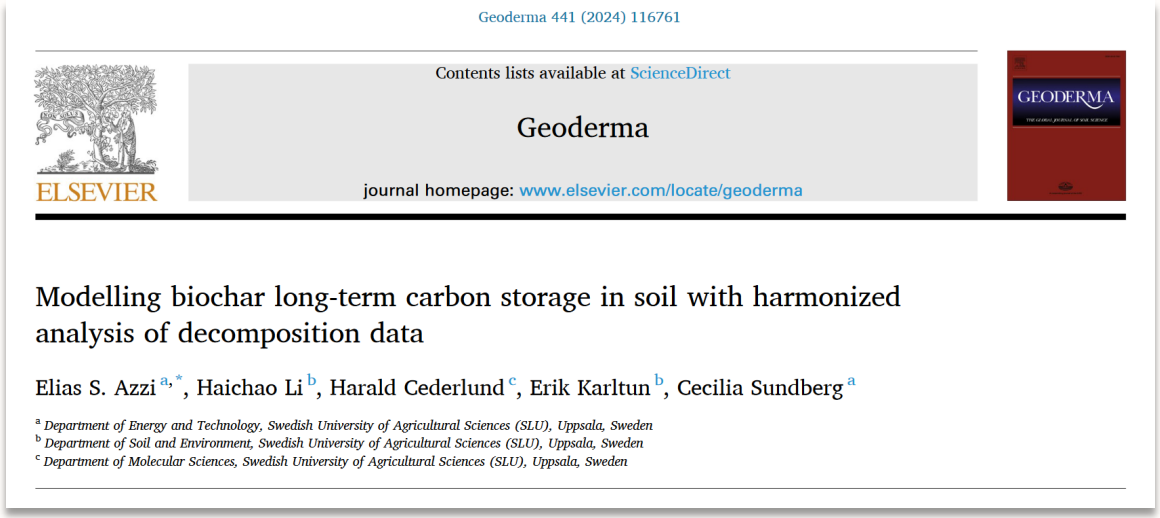
High durability and co-benefits present a unique combination in CDR

Better establish permanence

- Typically considered 100–1,000 year storage
- New data suggest majority of carbon in high temperature biochar persist >1,000 year

Highlight co-benefits

- End-use benefits
- Reduced air pollution from pile burning
- Process produces energy -> no competition for alternative energy



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Modelling biochar long-term carbon storage in soil with harmonized analysis of decomposition data

Elias S. Azzi [a,*], Haichao Li [b], Harald Cederlund [c], Erik Karltun [b], Cecilia Sundberg [a]

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[c] Department of Molecular Sciences, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden

USBI Approach:

- **Convene science community around permanence**
- **Advocate for biochar in national and global forums**

Carbon: Develop Robust Insetting Pathways

Physical biochar offers an opportunity to reduce value-chain emissions

Feedstock
- Methane reduction

Production
- Biochar production
- Electricity / Fuels

End-Use
- Material replacement
- Increased soil carbon
- Reduced GHG emissions
- Reduced ag inputs

Value-chain insetting can be used to:
- Capture benefits not included in CDR credits
- Embed CDR credits / benefits and avoid additionality requirements

Key value chain types:
- Agribusiness: Inputs and end products
- Forestry
- Industrial materials

USBI Approach:
- **Develop biochar insetting guidance**
- **Increase awareness of pathway**

Co-Products: Focus on the Future

Creative approaches to produce heat, fuels, and hydrogen offer opportunity

Electricity is a preferred pygas use, but:

- Permits and interconnections are slow
- Wholesale rates are low in many areas

Alternative pygas uses:

- Process heat
- Liquid fuel production (e.g., SAF)
- Liquid for carbon sequestration
- Hydrogen
- Precursors for materials

USBI Approach:

- **Collaborate with experts to assess pathways**
- **Coordinate funding opportunities with DOE**

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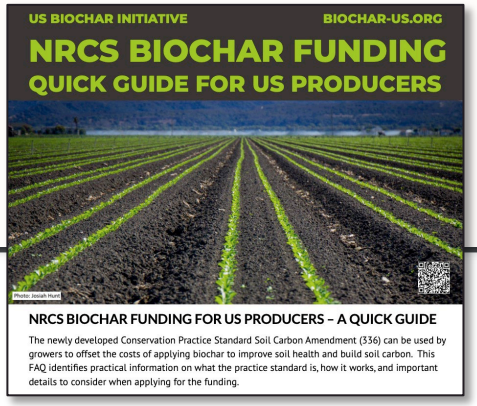
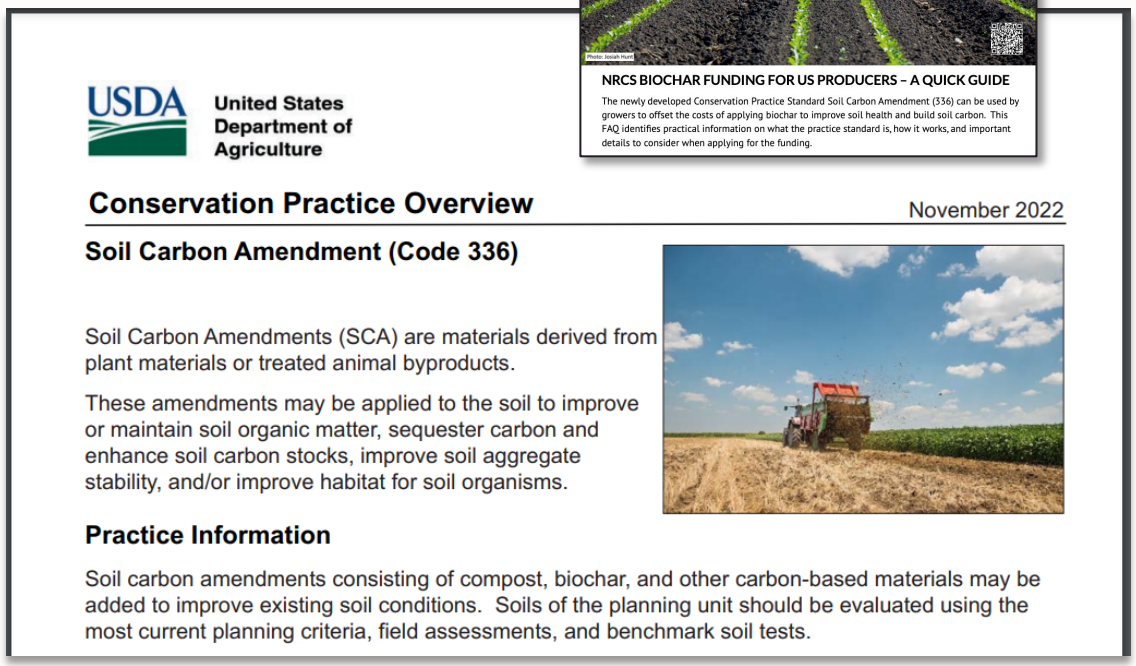
Markets: Biochar as a Soil Amendment

Scaling up deployment of federal cost share incentives for farmers



USDA Programs

- NRCS payments can provide funding for farmers to apply biochar
- Program recently launched
- Significant IRA and Farm Bill funding, but impact thus far unclear



USDA United States Department of Agriculture

Conservation Practice Overview November 2022

Soil Carbon Amendment (Code 336)

Soil Carbon Amendments (SCA) are materials derived from plant materials or treated animal byproducts.

These amendments may be applied to the soil to improve or maintain soil organic matter, sequester carbon and enhance soil carbon stocks, improve soil aggregate stability, and/or improve habitat for soil organisms.

Practice Information

Soil carbon amendments consisting of compost, biochar, and other carbon-based materials may be added to improve existing soil conditions. Soils of the planning unit should be evaluated using the most current planning criteria, field assessments, and benchmark soil tests.

USBI Approach:

- Pilots and demonstrations
- Knowledge sharing and awareness with **focus on growers and agribusiness**
- USDA funded projects
  - Biochar Atlas
  - Climate SMART Beef
  - DOE project with Washington State University
  - Chesapeake Scaling Up Biochar project

Markets: Beyond Soil Amendment

Focus on key markets identified during global survey

Biochar-enhanced fertilizers

Growing media

Composting

Restoration

USBI Approach:

- Support and promote industry-led projects
- Lead and support grant-funded technology R&D projects with end-use subject matter experts

Filtration

Materials

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Markets: Standards and Certifications

National and international standards, developed through official processes, are critical

Standards exist, but have limitations:

- Carbon Standards International
- International Biochar Initiative

USBI Approach:

- Develop North American standards that are
  - Trusted by industry and researchers
  - Feasible for US laboratories and biochar producers
  - Developed through official process including advisory board and public comments
  - Low cost to support early-stage industry

Key Limitation: Laboratories

- Existing biochar standards use diverse laboratory methods that are difficult for accredited US labs
- Few US laboratories offer biochar analysis

Standards that follow ISO or ASTM Methods are key

Thank you!

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