CHRYSALIX
VENTURE CAPITAL

Carbon neutral and waste to value opportunities

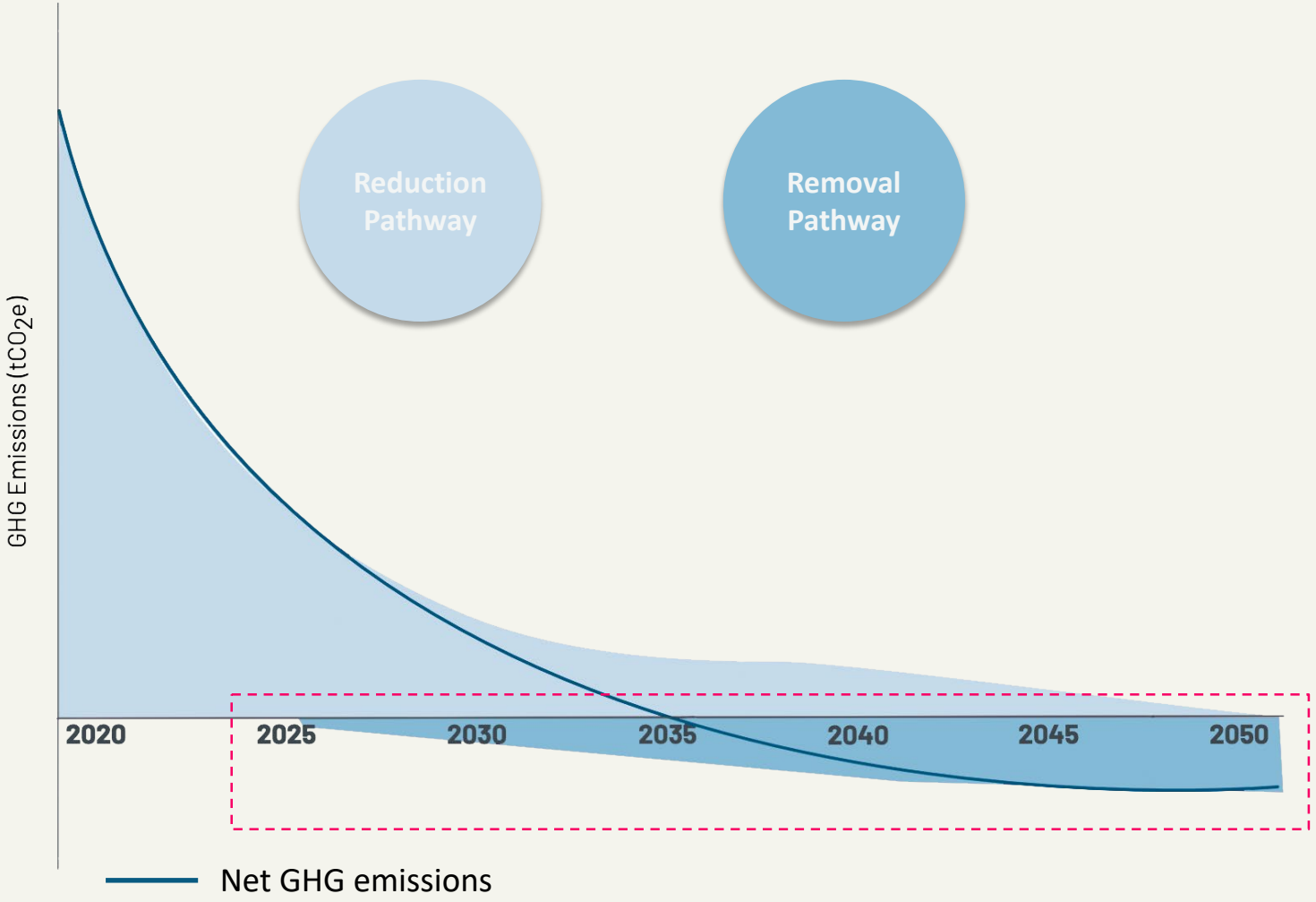
Fred van Beuningen, 7th forest & wood innovation forum, June 22nd, 2023

Carbon neutrality has become a strategic imperative

Companies are committing to net zero by 2050, some as early as 2030

How companies achieve their net zero targets

CO2 removal required as early as 2030 to be net negative by 2050



Net Zero Pathway

1. **Reduce** emissions through deep decarbonization.
2. **Remove** emissions within and beyond own value chain.
3. **Compensate** emissions through offsetting.

Key carbon neutrality levers and technologies

Technologies with broad applicability to several industries

	PROCESS IMPROVEMENT	FUEL & FEEDSTOCK SWITCH	MATERIAL EFFICIENCY & SUBSTITUTION	CIRCULARITY	CCUS

REDUCE EMISSIONS	• Energy efficiency ●●●●●●
	• Automation ●●
		• Alternative fuels ●●
		• Renewable energy ●●●●●●
		• Electrification ●●●●●●
		• Biomass ●●
		• Hydrogen ●●●●●
		• Nuclear fusion ●
			• Alternative & novel materials ●●
			• Biobased materials ●
			• Synthetic fuels ●●
				• Secondary raw materials ●●●●
				• Waste sorting & recovery/recycling ●●●
				• Waste-to-value ●●●●
					• Capture ●●●●●●
					• Utilization ●●●●●●
					  • Mineralization
					  • Chemical
					  • Biological
					• Storage ●●●●●●

	CARBON CREDITS	NATURE-BASED SOLUTIONS	BECCS	DACCS
REMOVE EMISSIONS	• Analytics, trading and sale	• Land Management • Forest Management • Ocean Fertilization	• Biomass for energy (incl. CO2 capture)	• Geological storage • Mineralization

● Cement, ● Chemicals, ● Iron & Steel, ● Mining, ● Oil & Gas, ● Power, ● Transport

CCUS: Carbon Capture Utilization and Storage; **CCS**: Carbon Capture and Storage;
DACCS: Direct Air Capture with Carbon Storage; **BECCS**: Bio-energy with carbon capture and storage

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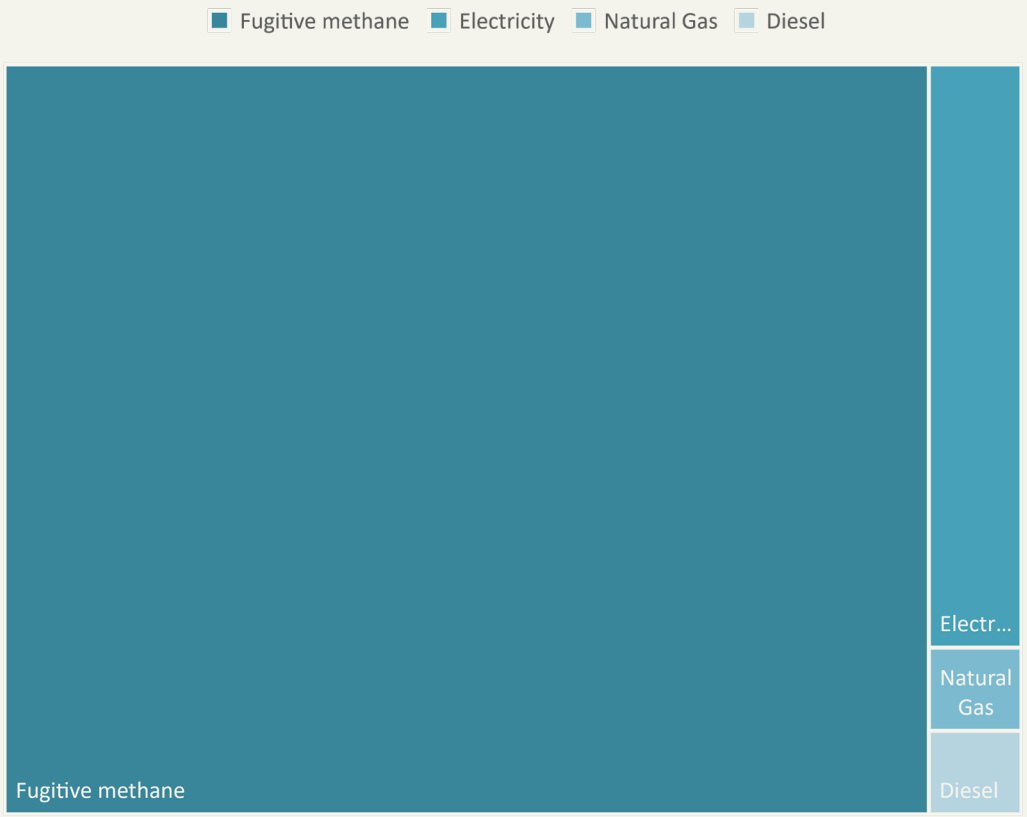
Example: Mining

1.9 to 5.1Gt GHG emissions annually (~4 to 7% of global emissions)

SIZE & SOURCE



TECHNOLOGY LEVERS

Renewable energy
- Renewable electricity generation
- Energy storage
- Smart microgrids
- Mine site remediation & reclamation

Electrification & automation
- Trucking & transport
- All-electric mine
- New enabling sensors
- Advanced AI & data analytics (predictive or real-time)
- Continuous mining

Process & technology innovation
- Efficiency improvement
- Grade engineering / precision mining
- Energy-efficient comminution
- Robotic inspection & maintenance
- Mineral processing

Waste-to-value
- Metal recycling
- Secondary production
- Waste to value: waste dumps and tailings

Waste to Value Opportunities

Framework for Evaluation of the Value Proposition & Economics

Feedstock

- Access to concentrated or abundant feedstock
- Feedstock specifications
  - Annual supply (volume / mass)
  - Composition
- Pre-processing requirements
- Geographic constraints
- Feedstock cost/value
- Current treatment of waste (venting / flaring)

Conversion & Transport

- CAPEX
  - Modularity
  - Balance of plant
  - Requirement of large- scale pilot/ demo
- OPEX
  - Labor
  - Energy
  - Consumables
- Performance metrics
  - Yield
  - Throughput

Product

- Market applications and value streams
- Product price and volatility
- Value to volume ratio
- Product specifications
  - Input for product or process
  - Commodity product
  - Annual production (mass / volume)
- Post-processing and sorting
- Geographic limitations
- Logistics cost

2nd generation products from biomass

Pathway to chemicals, materials and fuels

- ✓ Second generation products from waste biomass avoiding competition with food crops
- ✓ After pretreatment lignocellulosic biomass can be converted to several industrially relevant chemicals
- ✓ Lignocellulosic biomass's composition is variable, and pretreatment can produce process-limiting compounds
- ✓ Valorizing lignin, due to its complex composition and poor properties have not yet resulted in large-scale applications
- ✓ Consumer-facing brands have established downstream partnerships with a few leading startups, with the most interest directed toward the development of second-generation packaging material
- ✓ Emerging companies valorizing lignocellulosic feedstocks are developing a wide array of second-generation products

Innovation

Industry collaboration, technology developers upstream and down stream