Spring 2022 Yale Forest Forum (YFF)Webinar Series

The Future of Forest Products in a Changing Climate: ***Bioenergy from Forests***

YFF Webinar on BioEnergy from Forests (BEF)

1. Introductions
2. Webinar Basics
3. Guest Speakers
4. BEF Overview
   - Life cycle overview, process map
   - Types of conversion technologies
   - BEF and energy consumption
   - Issues of contention for BEF

Introductions

- Welcome
- Host Organizations:
  - Yale Carbon Containment Lab
  - Yale Center for Industrial Ecology
  - The Forests Dialogue
- *Series Objective*: to provide a broad and engaged global audience with the latest information from key experts on the opportunities and challenges of BEF
- Series Facilitators

Series Facilitators

Mark Ashton

Professor of Silviculture and Forest Ecology, and the Director of the Yale Forests, The Forest School at the Yale School of the Environment

Anastasia O'Rourke

Managing Director at the Carbon Containment Lab, Yale School of the Environment

Reid Lifset

Research Scholar, Resident Fellow in Industrial Ecology, and Editor-in-Chief of the Journal of Industrial Ecology, Yale School of the Environment

Gary Dunning

Executive Director of the The Forests Dialogue (TFD), The Forest School at the Yale School of the Environment

Webinar Basics

- 2nd YFF Series on Forest Products in a Changing Climate
- Will meet every Tuesday from January 25 to April 19
  - From 11:30 – 12:15 US ET
- Format: After brief introduction, guest speakers present for 25-30 minutes leaving about 10 minutes for Q&A with the audience
- Webinars are open to all via registration
- All Webinars will be recorded and made accessible
- More information can be found on YFF Website including:
  - Speaker bio, talk title and abstract, associated readings
  - Plus, after the presentation, slides and talk recording
- All talks will be summarized and compiled in the next edition of the *YFF Review* publication focused on "BioEnergy from Forests"

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The Forest School

Webinar Themes and Speakers

Week 2 Theme: Biomass and Land Use

Alice Favero

School of Public Policy, Georgia Tech

Week 3 Theme: The Industrial Ecology of BEF

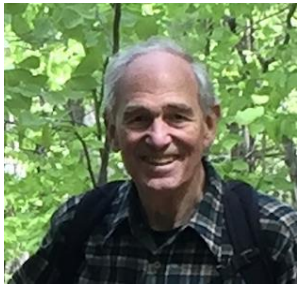
Annie Levasseur

École de technologie supérieure, ÉTS

Week 4 Theme: Conservation and 'right sizing' BEF

Steve Hamburg

Environmental Defense Fund



Week 5 Theme: Key Environmental Challenges of BEF

William Moomaw

The Fletcher School - Tufts

Week 6 Theme: BEF Opportunities for the Forest Products Industry

Kim Cesafsky DuBose

Enviva Inc.

Week 7 Theme: Energy Industry's Interest in BEF

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Concerned Citizens of Cook County

Adam Colette

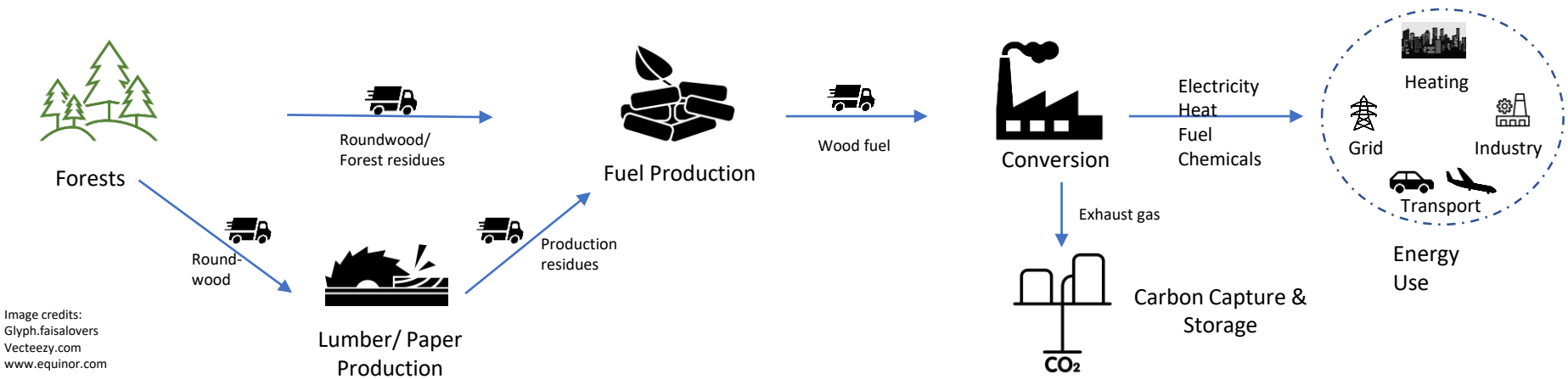
Dogwood Alliance

Week 12 Theme: US and Global Policy Matters Related to BEF

Ann Bartuska

Resources for the Future

Wood Bioenergy System Overview



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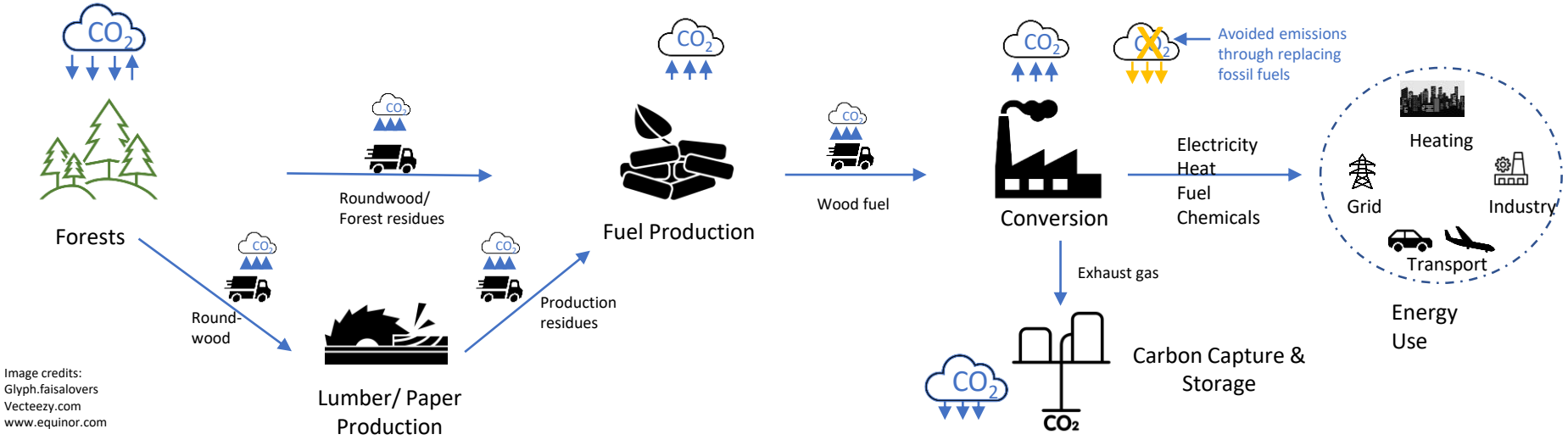
Vecteezy.com
www.equinor.com

Wood Bioenergy System Overview: CO_2



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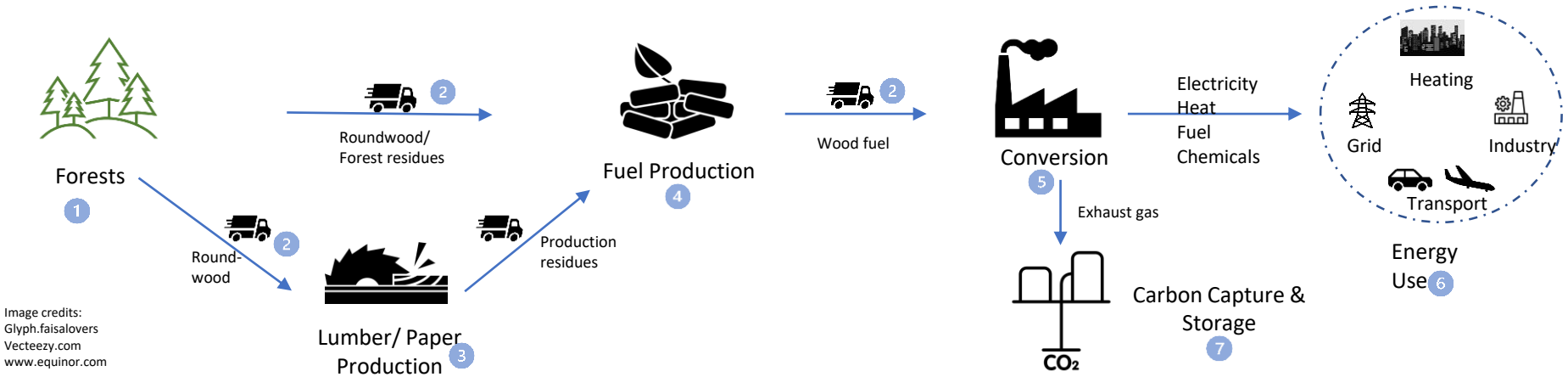
Wood Bioenergy System: Environmental impacts



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1 Forest

- Water quality
- Habitat loss/biodiversity
- Soil impacts
- Landscape change
+ Fire risk reduction
+ Forest restoration

2 Transport

- Air emissions

3 Lumber & Paper Production

- Water quality
- Air emissions

4 Fuel Production

- Air emissions

5 Conversion

- Air emissions
- Noise
- Hazardous & nonhazardous wastes

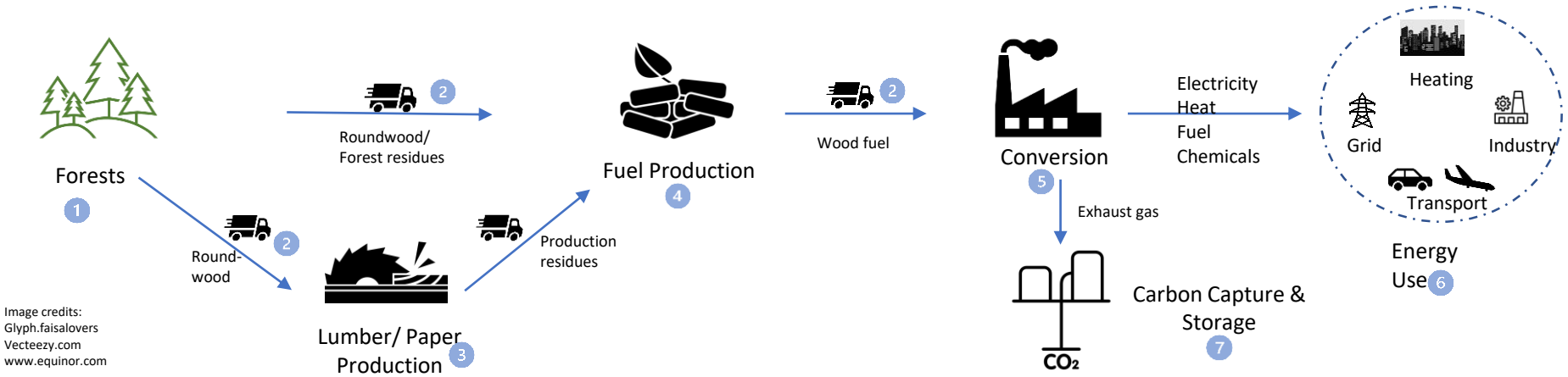
6 Energy Use

- Air emissions

7 Carbon Capture & Storage

- Air emissions

Wood Bioenergy System: Social & Economic Impacts



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1 Forest
- \- Visual aesthetics
- \- Cultural, historical & archeological sites
- -/+ Recreation/land use change
- \+ Income to landowners
- \+ Jobs
- \+ Tax revenues
- \+ Prevention of forest conversion

2 Transport
- \- Health impacts
- \- Environmental justice
- \- Traffic
- \- Safety
- \+ Jobs

3 Lumber & Paper Production
- \- Health impacts
- \- Environmental justice
- \- Safety
- \+ Income to facility owners
- \+ Jobs
- \+ Tax revenues

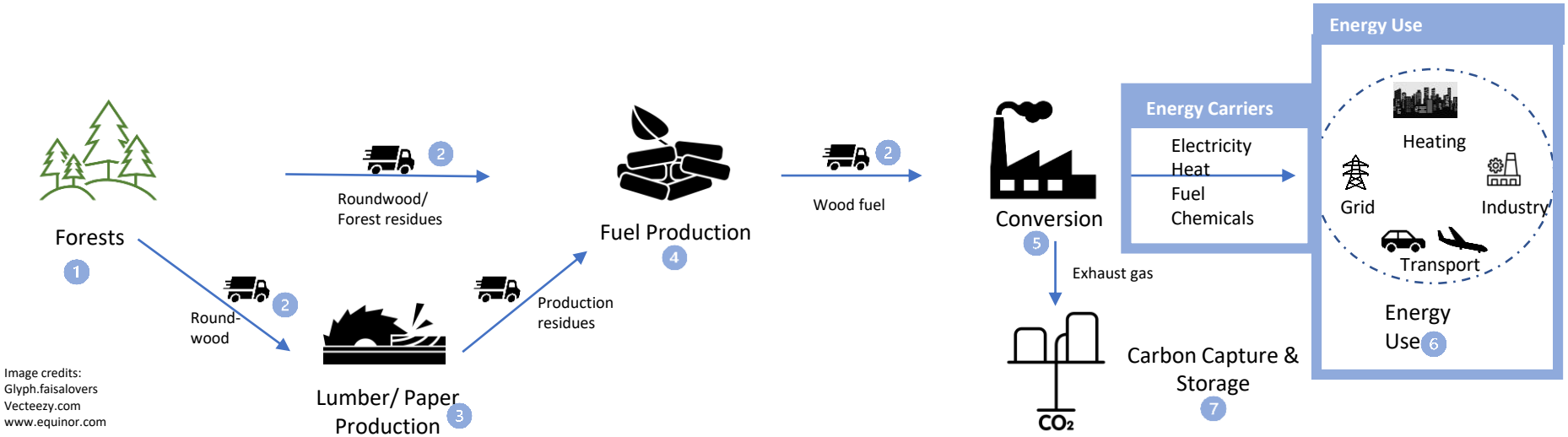
4 Fuel Production
- \- Health impacts
- \- Environmental justice
- \- Safety
- \+ Income to facility owners
- \+ Jobs
- \+ Tax revenues

5 Conversion
- \- Health impacts
- \- Environmental justice
- \- Safety

6 Energy Use
- \- Health impacts
- \+ Energy security
- \+ Reduced energy price volatility

7 Carbon Capture & Storage
- \- Health impacts
- \- Environmental justice
- \+ Income to facility owners
- \+ Jobs
- \+ Tax revenues

Wood Bioenergy System: Diving deeper



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1 Sources

Bioenergy from Forests

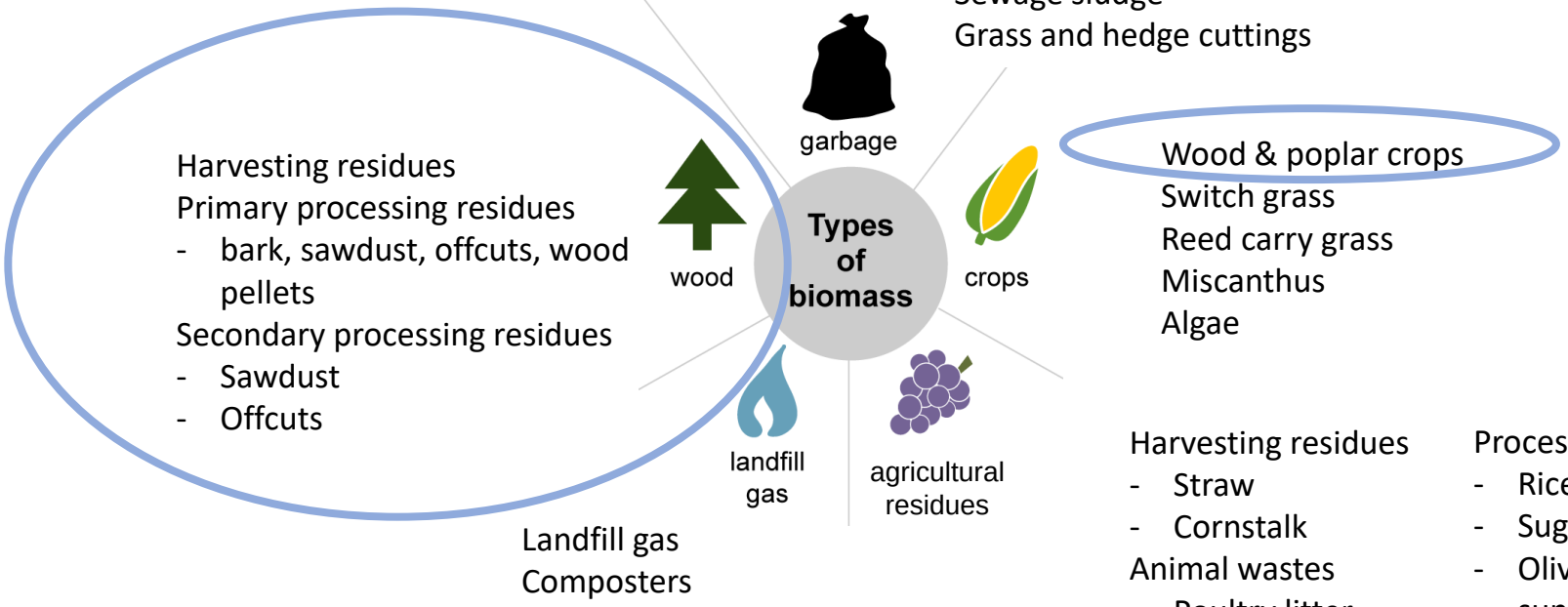
5 Conversion

Combustion

Gasification

Pyrolysis

Biomass Energy Sources



Municipal solid waste
Refuse derived fuel
Solid recovered fuel
Scrap tires
Wood wastes
Sewage sludge
Grass and hedge cuttings

Harvesting residues
Primary processing residues
- bark, sawdust, offcuts, wood pellets

Secondary processing residues
- Sawdust
- Offcuts

Landfill gas
Composters

Wood & poplar crops
Switch grass
Reed carry grass
Miscanthus
Algae

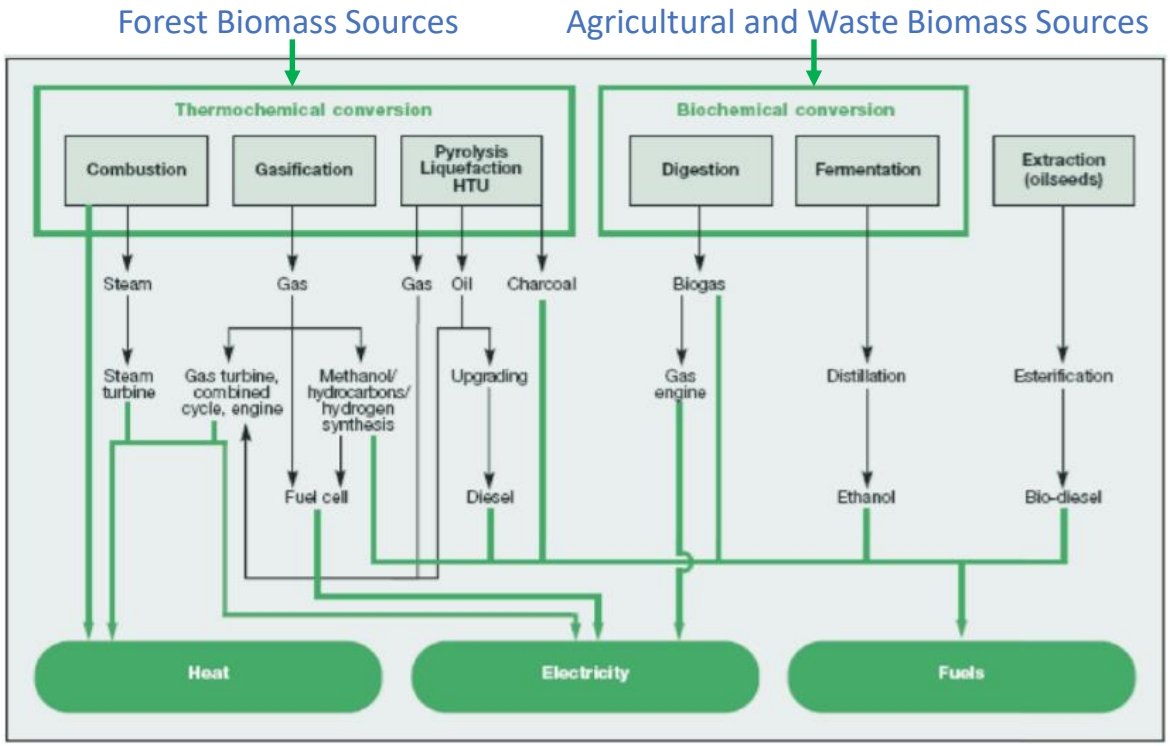
Harvesting residues
- Straw
- Cornstalk

Animal wastes
- Poultry litter
- Tallow
- Meat & bone meal

Processing residues
- Rice husks
- Sugarcane bagasse
- Olive, palm oil, sunflower husks
- Fruit residues
- Cereal residues

Source: IEA 2016, 20222

Bioenergy Conversion Pathways

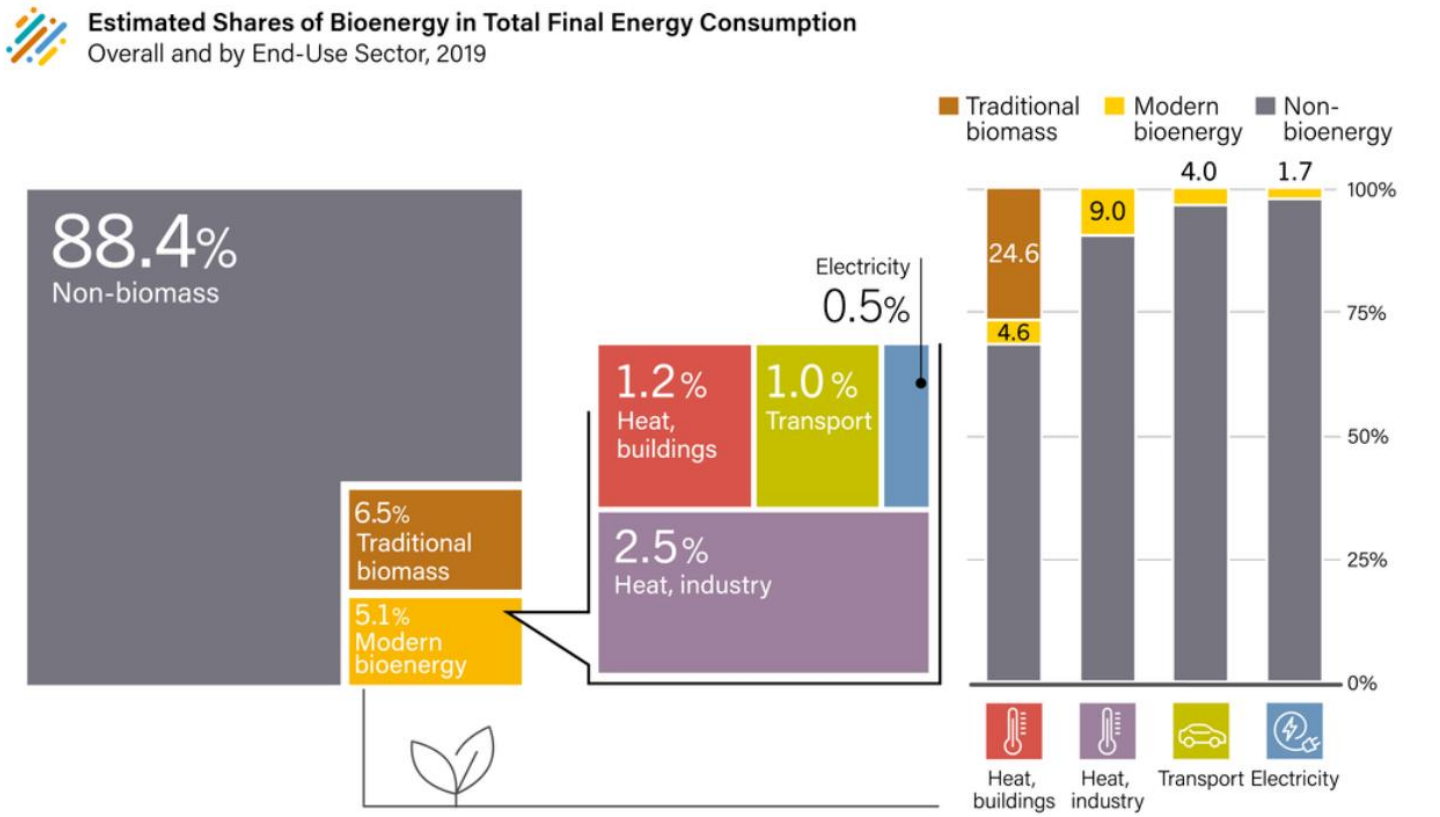


Main conversion routes for biomass to secondary energy carriers.

Different systems combine different technologies and generate a range of energy and non-energy products.

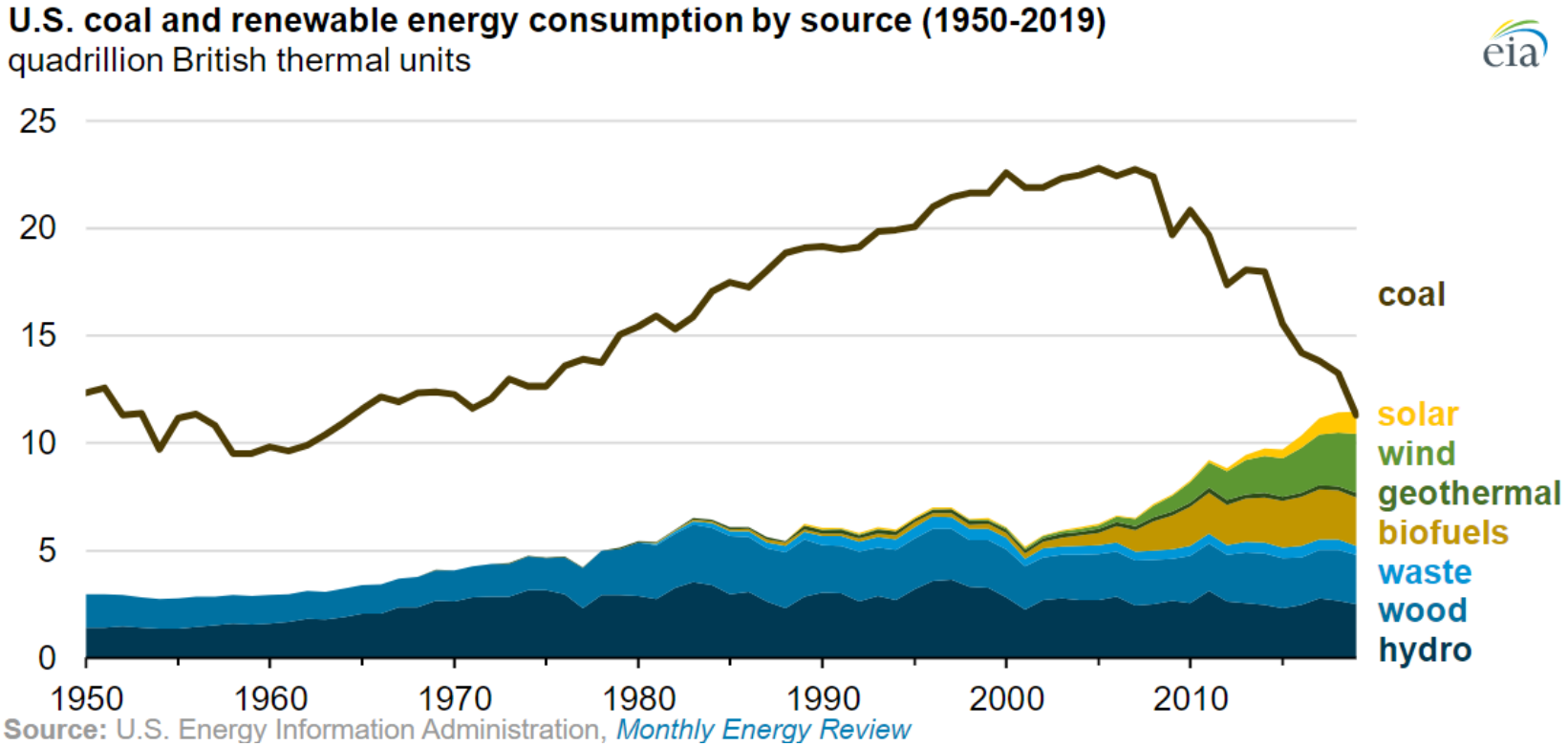
Adapted from: Global Energy Assessment: Chapter 11: Renewables 2012, and UNDP, 2000

Bioenergy's share of global total energy consumption

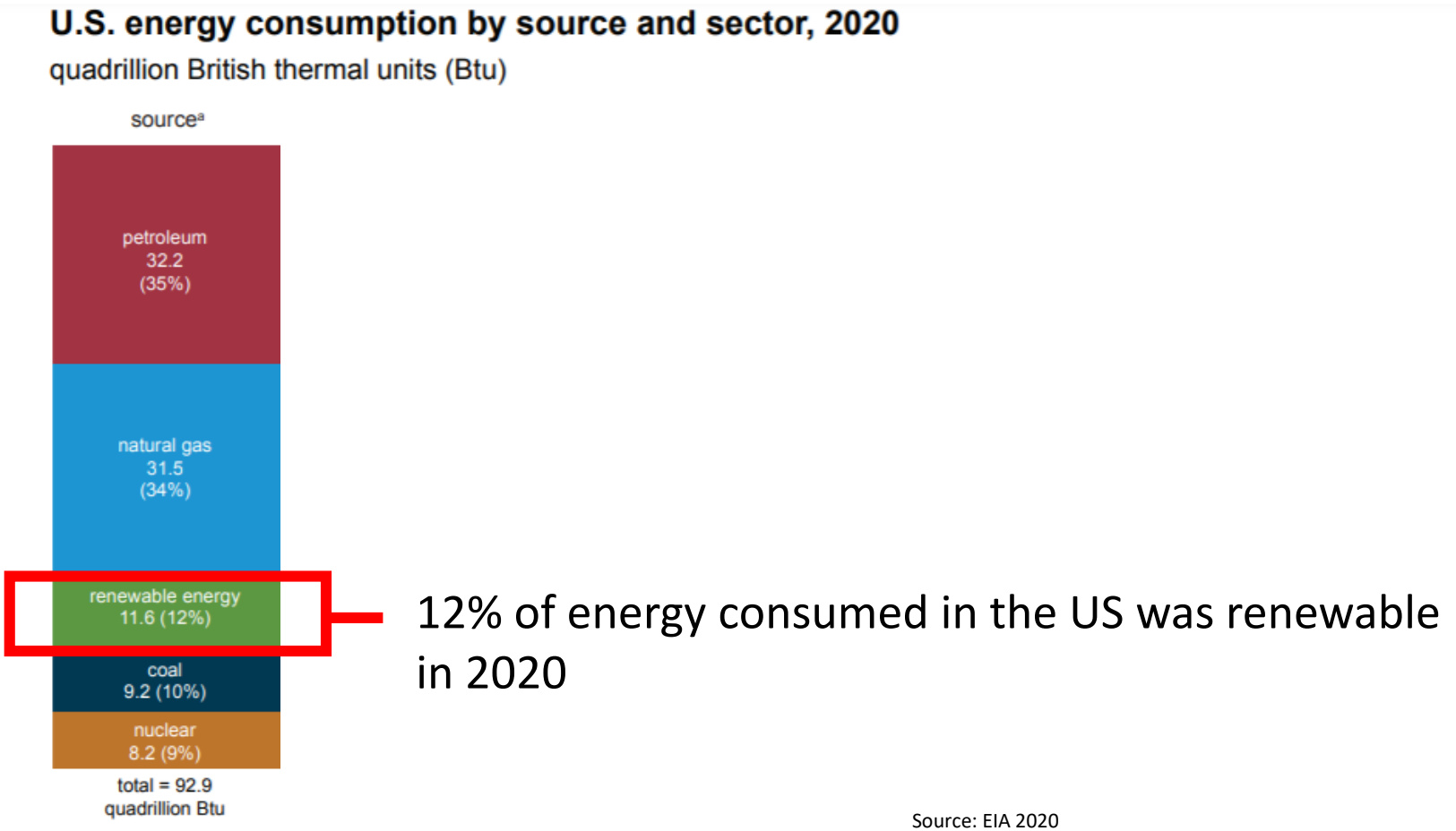


Source: REN21, 2021: https://www.ren21.net/gsr-2021/chapters/chapter_03/chapter_03/

Energy consumption by source in the U.S.

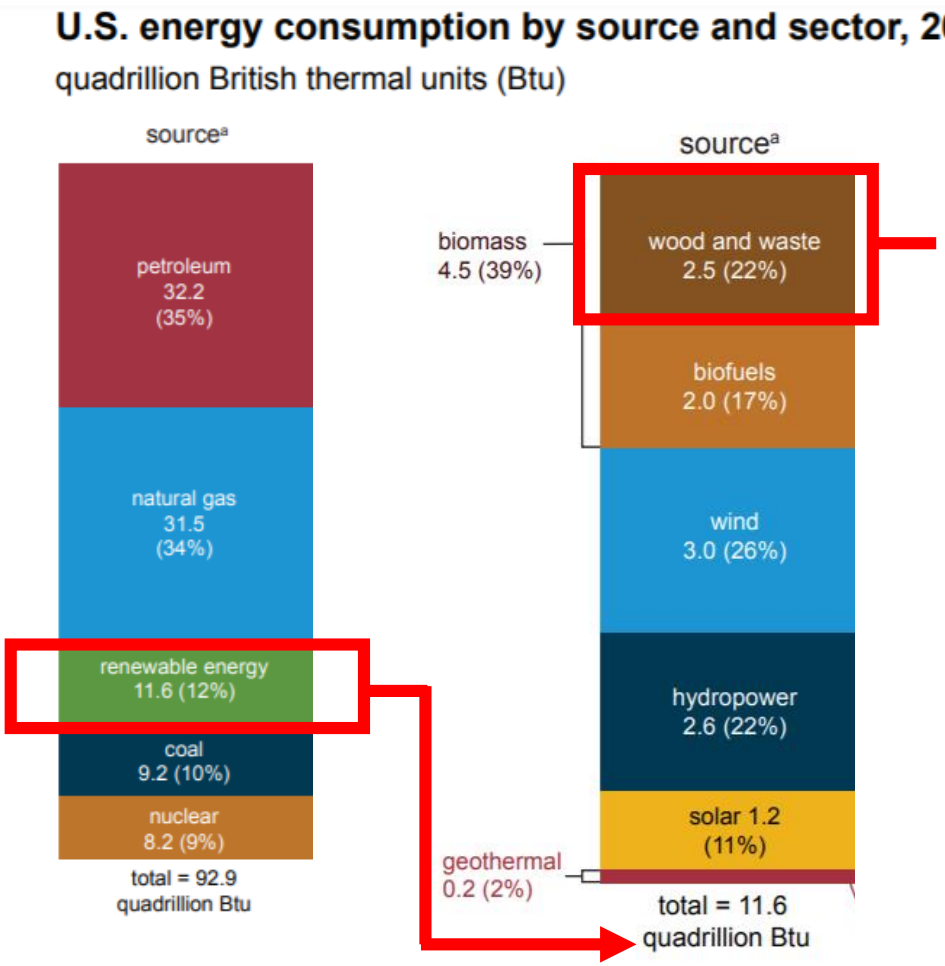


2020 https://www.eia.gov/todayinenergy/detail.php?id=43895



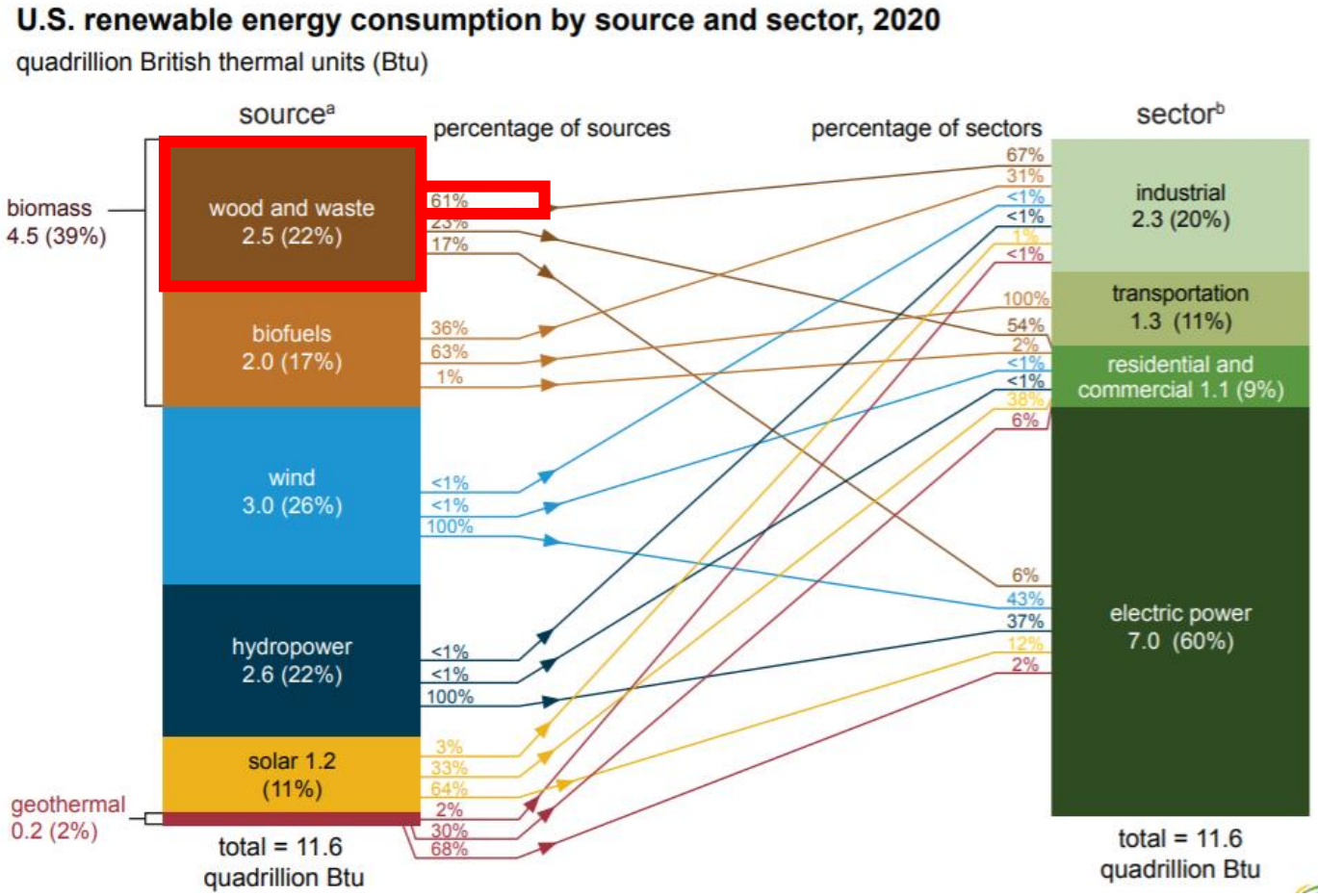
12% of energy consumed in the US was renewable in 2020

Source: EIA 2020
https://www.eia.gov/totalenergy/data/monthly/pdf/flow/total_energy_2020.pdf



2.7% of total energy consumed in US in 2020

Source: EIA 2020
https://www.eia.gov/totalenergy/data/monthly/pdf/flow/total_energy_2020.pdf
https://www.eia.gov/totalenergy/data/monthly/pdf/flow/renewable_energy_2020.pdf



61% of bioenergy from wood and waste is consumed by industrial sector

Source: EIA 2020
https://www.eia.gov/totalenergy/data/monthly/pdf/flow/total_energy_2020.pdf
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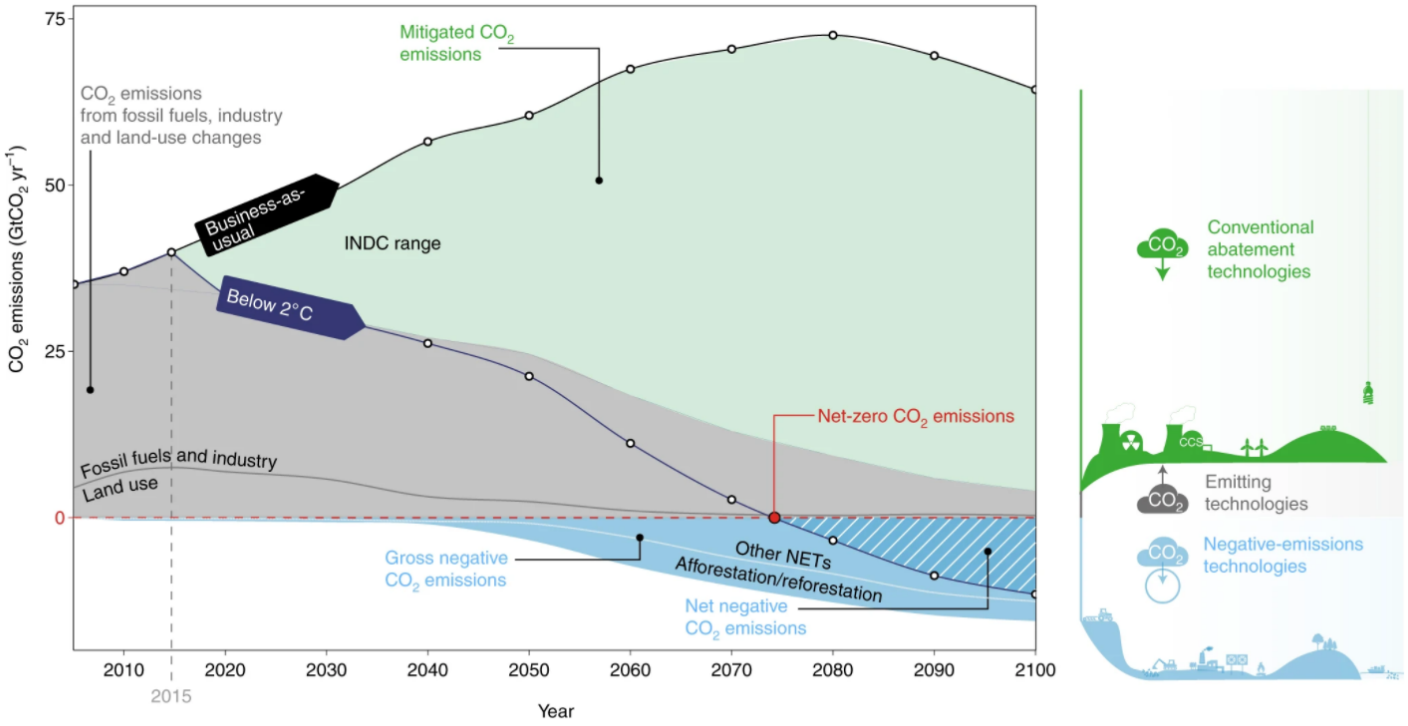
Bioenergy as a “negative emissions” technology?



a, Global CO_2 emission pathways from the scenario literature. **b**, Examples of technologies. Reproduced from ref. [1]. INDC; Intended Nationally Determined Contributions

Source: Yan, J in *Nature Climate Change* 2018 https://www.nature.com/articles/s41558-018-0215-9/figures/1

BioEnergy from Forests – Issues of contention

"Currently the most fiercely debated forest issue in North America and Europe"

- Pellets shipped to Europe
- Forest certification
- Access to Federal Lands
- Climate mitigation and clean energy
- Carbon accounting
- Market for biomass
- Siting of facilities
- Environmental justice

Questions?

Thank you!

Contact us:

The Forest School at the Yale School of the Environment

forestry@yale.edu

https://environment.yale.edu/forest-school

Instagram and Twitter at @YaleForestry

The Yale Forest Forum

yff@yale.edu

https://yff.yale.edu/

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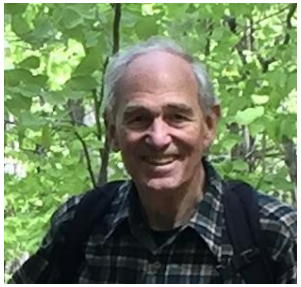

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