Forest carbon or forest bioenergy?

Assessing trade-offs in GHG mitigation

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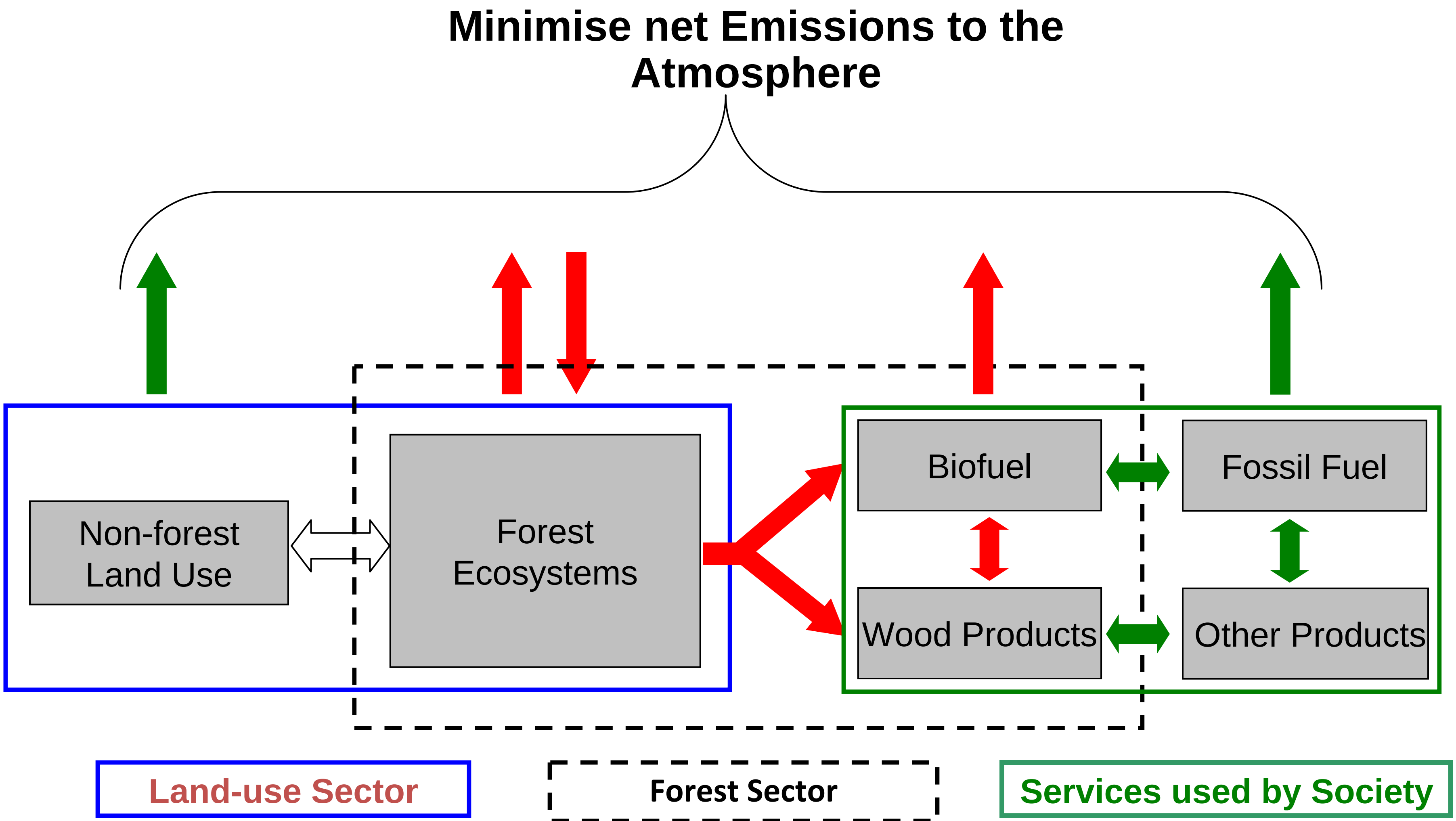
Outline

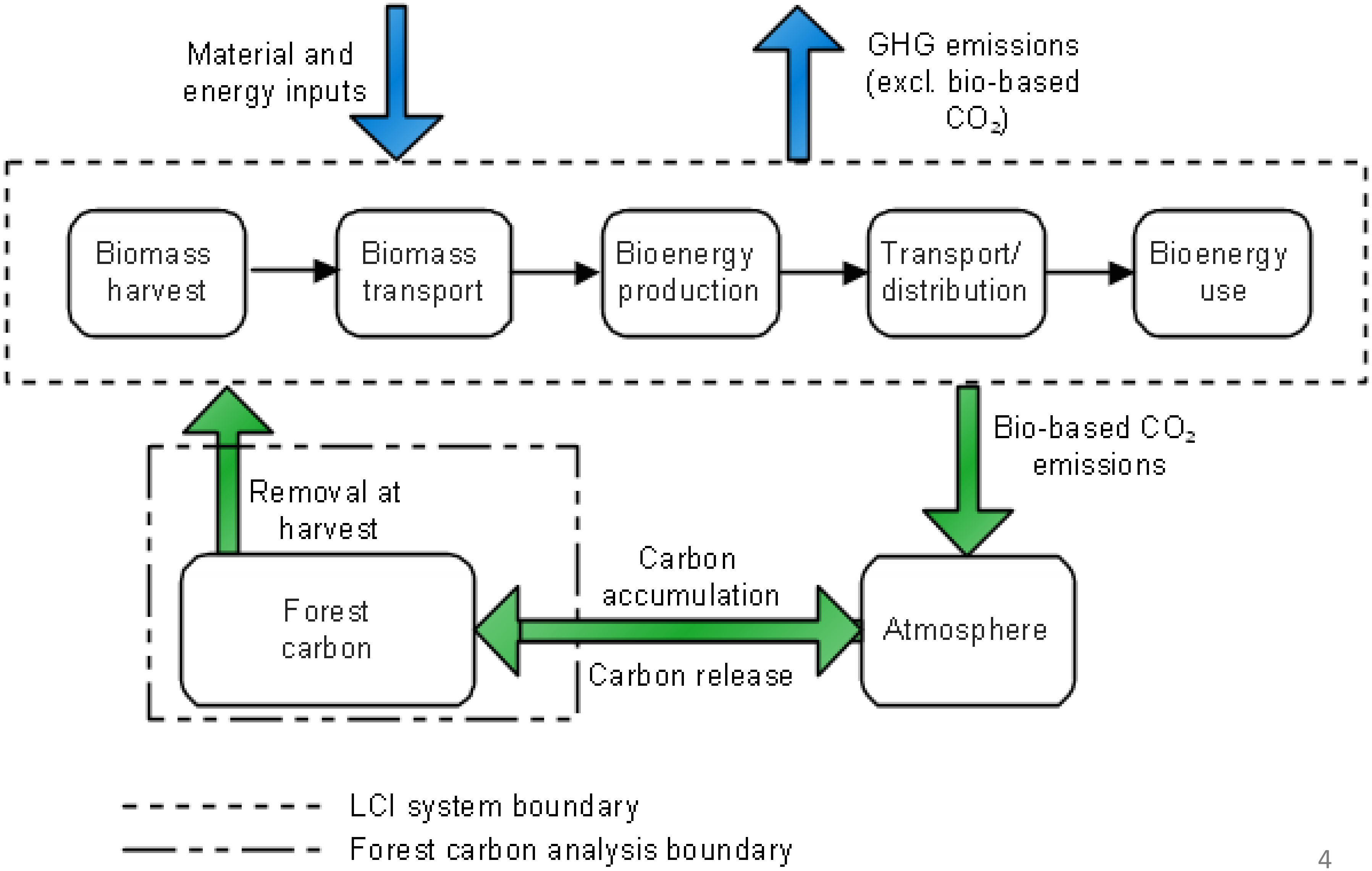
- Bioenergy and forest carbon
- Framework for assessing Total GHG Emissions from forest bioenergy
    - Wood pellets, Ethanol
    - Standing trees, Harvest residues
- Moving forward: Improving Total GHG Emissions of ethanol produced from woody biomass
- Key messages

Bioenergy in the context of forest options for GHG mitigation

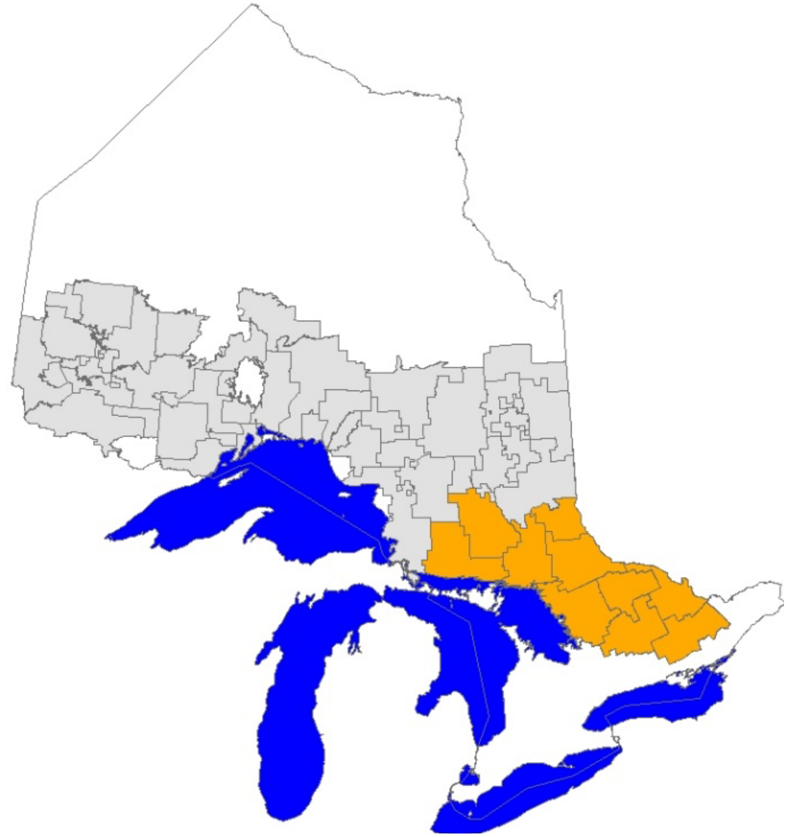


Modified from IPCC 2007, AR4 WG III, Forestry

Framework for assessing Total GHG Emissions of forest bioenergy



Application of framework



Bioenergy products
- Wood pellets
- Ethanol

Biomass sources
- Standing trees
- Harvest residues
- Sourced from Great Lakes – St. Lawrence Forest Region of Ontario

Bioenergy pathways considered

Electricity generation

- Wood pellets at retrofit Nanticoke Generating Station: 20% co-firing with coal; 100% pellet
- Coal-only generation at Nanticoke

Transportation

- Ethanol (E85 blend) for use in light-duty vehicle
- Reformulated gasoline for use in LDV

Forest carbon modeling approach

- Compare forest carbon storage in GLSL region under:

  Harvest *'without'* bioenergy

  - (traditional products only, historic harvest rate)

  Harvest *'with'* bioenergy

  - (traditional products and wood pellets/ethanol)
- Difference in forest carbon is allocated to wood pellets
- Continuous production over 100 years

Key assumptions

Trees not harvested for bioenergy:

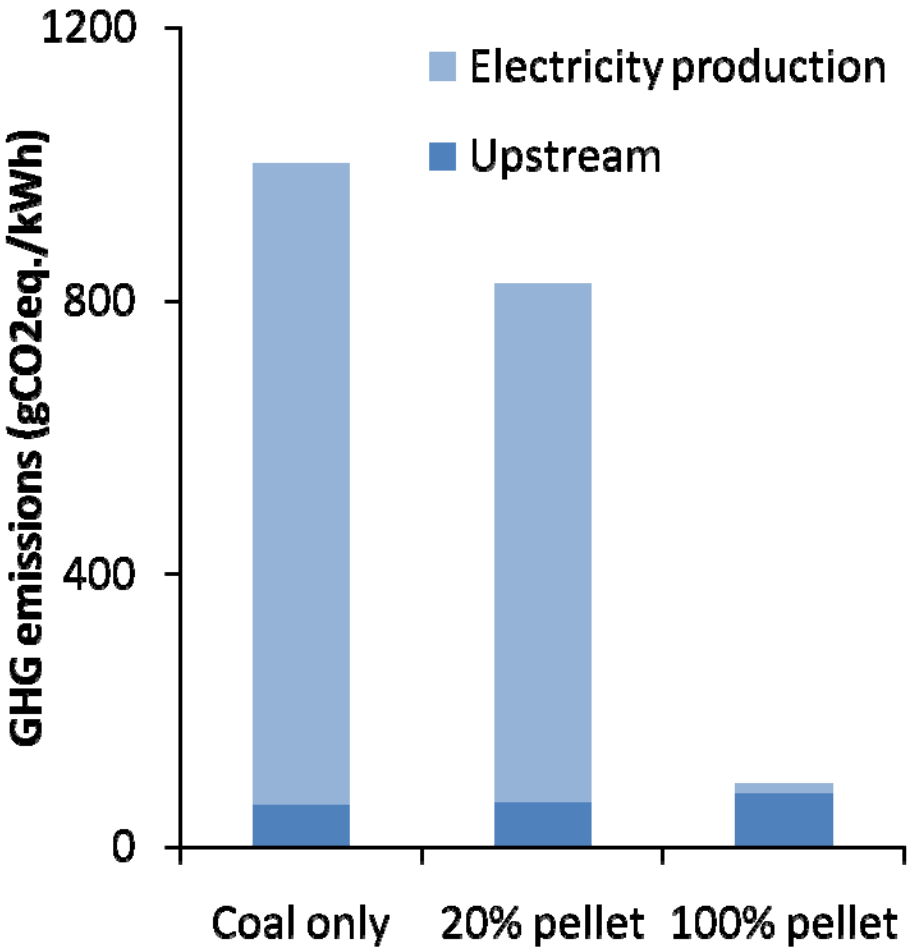
- Not harvested for other uses
- Age and undergo natural succession
- Subject to current rate of disturbance

Harvest residues not collected for bioenergy:

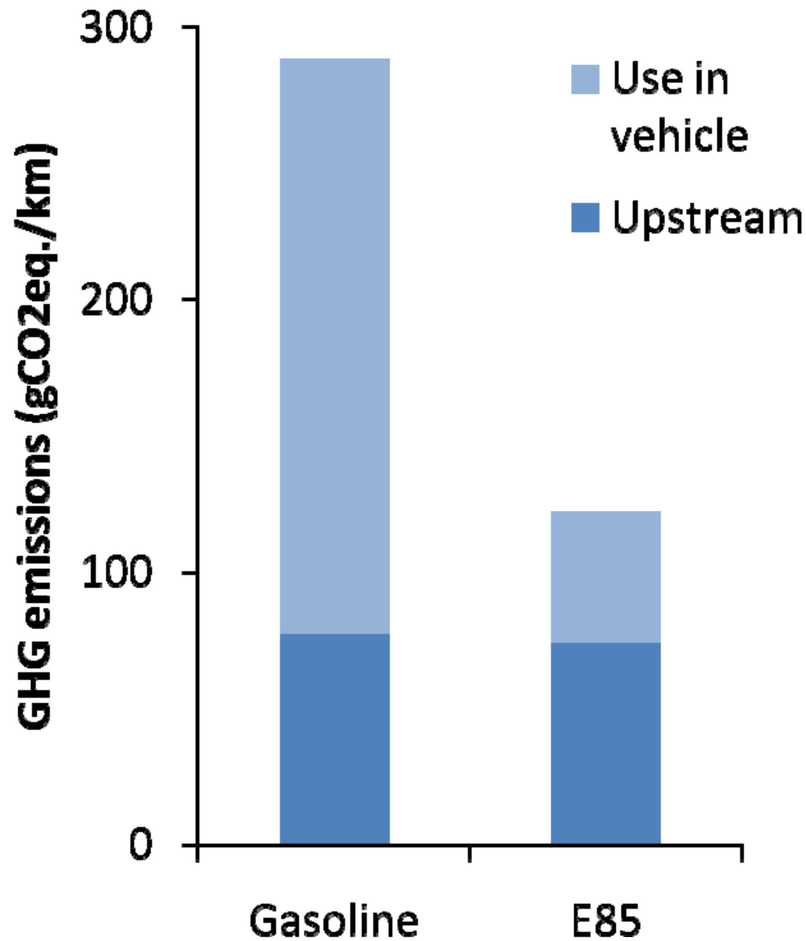
- Not collected for other uses
- Decompose in the forest

GHG emissions, excluding forest C

Electricity pathways



Transportation pathways



GHG emissions results, including forest C:

1. Pellets, EtOH initially increase GHG emissions

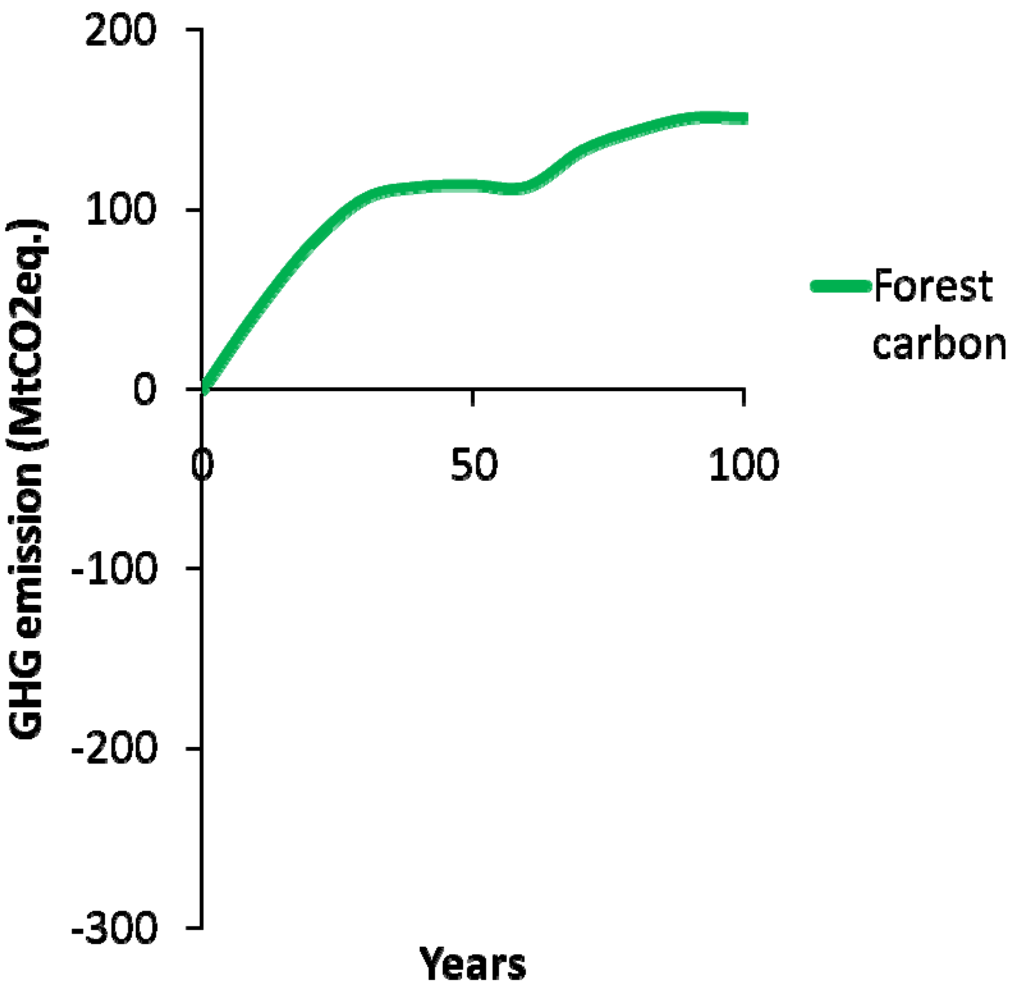
Life cycle emissions, excluding forest C
~90 gCO_2eq/kWh

Bio-based emissions:
~1,100 gCO_2eq/kWh

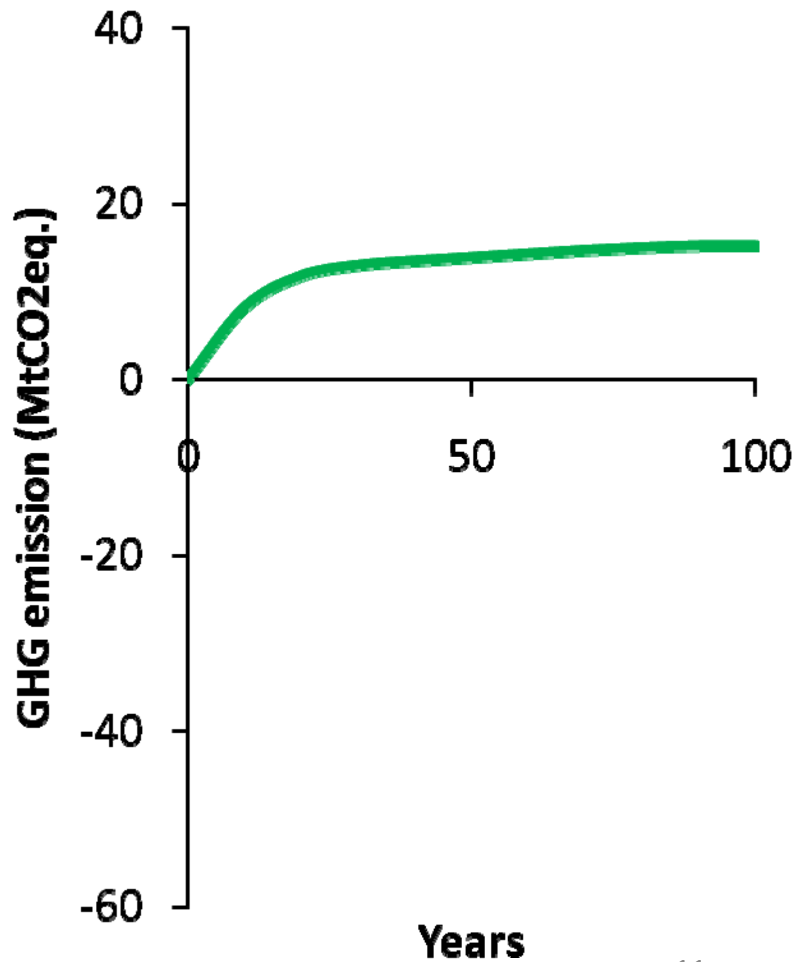
Life cycle emissions
~1,000 gCO_2eq/kWh

2. Forest carbon impacts of biomass harvest tend toward an equilibrium

Standing tree



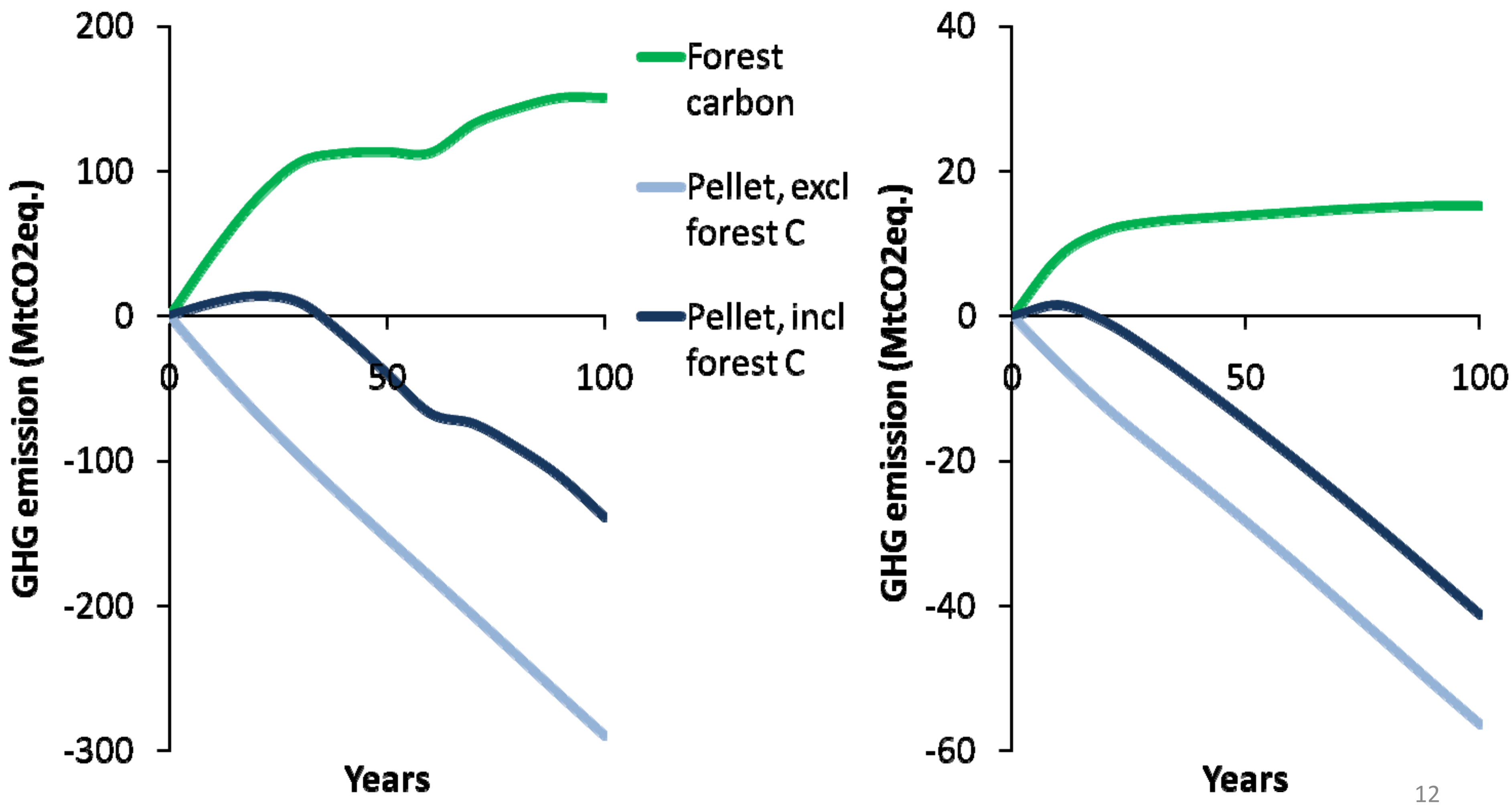
Harvest residue



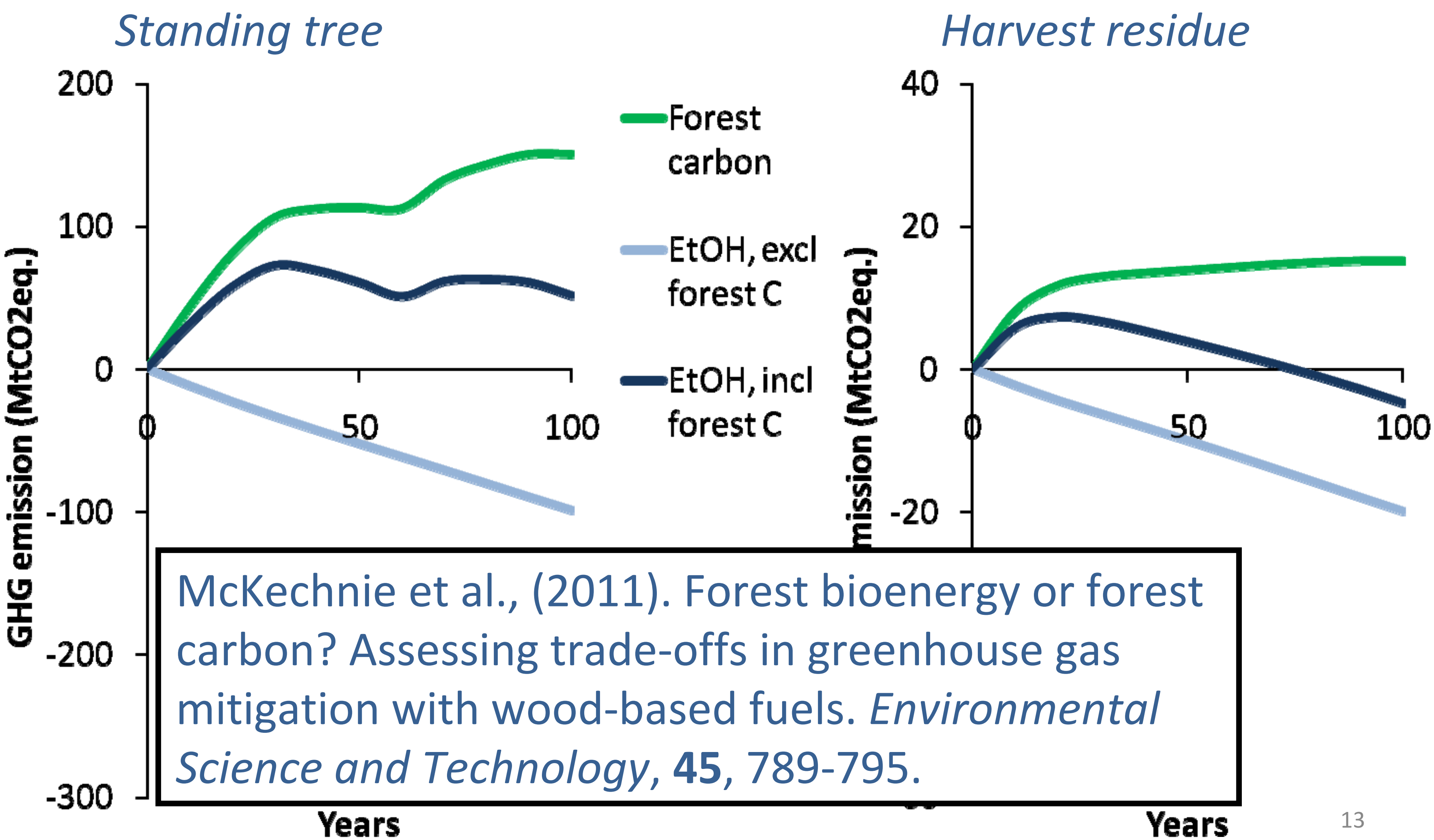
3. Forest carbon impacts reduce and delay GHG mitigation (pellets, displ. coal)

Standing tree

Harvest residue



4. Less favourable GHG balance when displacing lower-GHG fuels (EtOH)



McKechnie et al., (2011). Forest bioenergy or forest carbon? Assessing trade-offs in greenhouse gas mitigation with wood-based fuels. *Environmental Science and Technology*, **45**, 789-795.

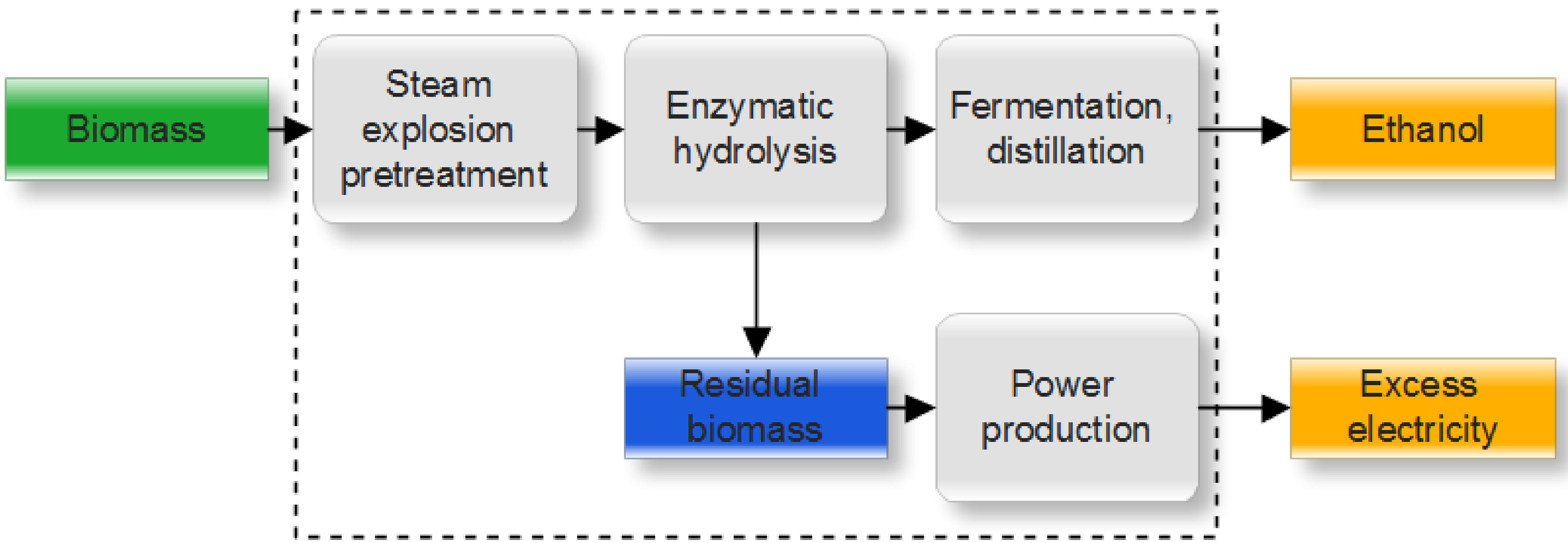
Can the Total GHG Emissions of forest bioenergy be improved?

- Reducing the forest carbon impact of biomass provision
    - Non-forest sources (process residues, end-of-life materials)
    - Target specific species groups, age classes
    - Forest management intensity
- Improving the GHG benefit of bioenergy
    - Make 'best use' of bioenergy to maximize GHG displacement
    - Bioenergy production decisions, co-products

Improving GHG emissions mitigation of ethanol from woody biomass

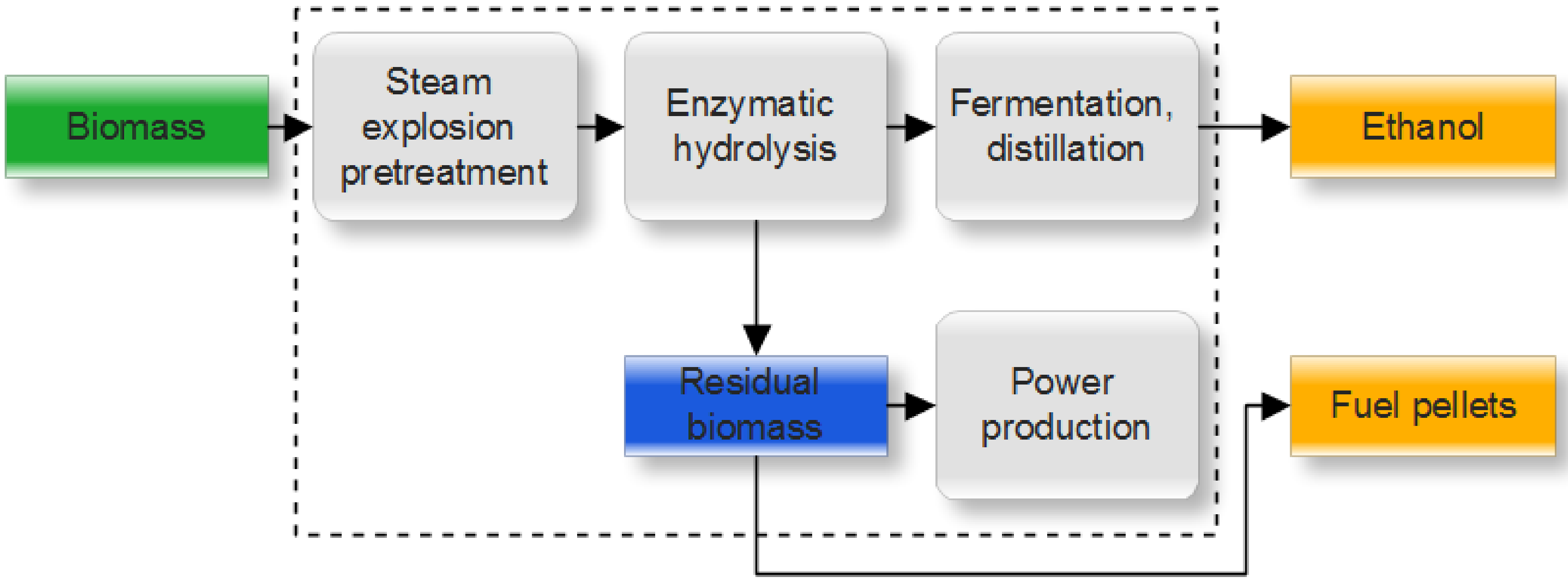
- Most studies of EtOH production assume a stand-alone facility exporting excess electricity co-product to the grid
- GHG balance of EtOH may be improved by considering:
  - Co-location with other processes
  - Broader range of co-products
  - Process energy sources
- Ethanol production process developed by SunOpta (now Mascoma Canada)
- Assume production in US Midwest from hybrid poplar

1. Electricity co-product



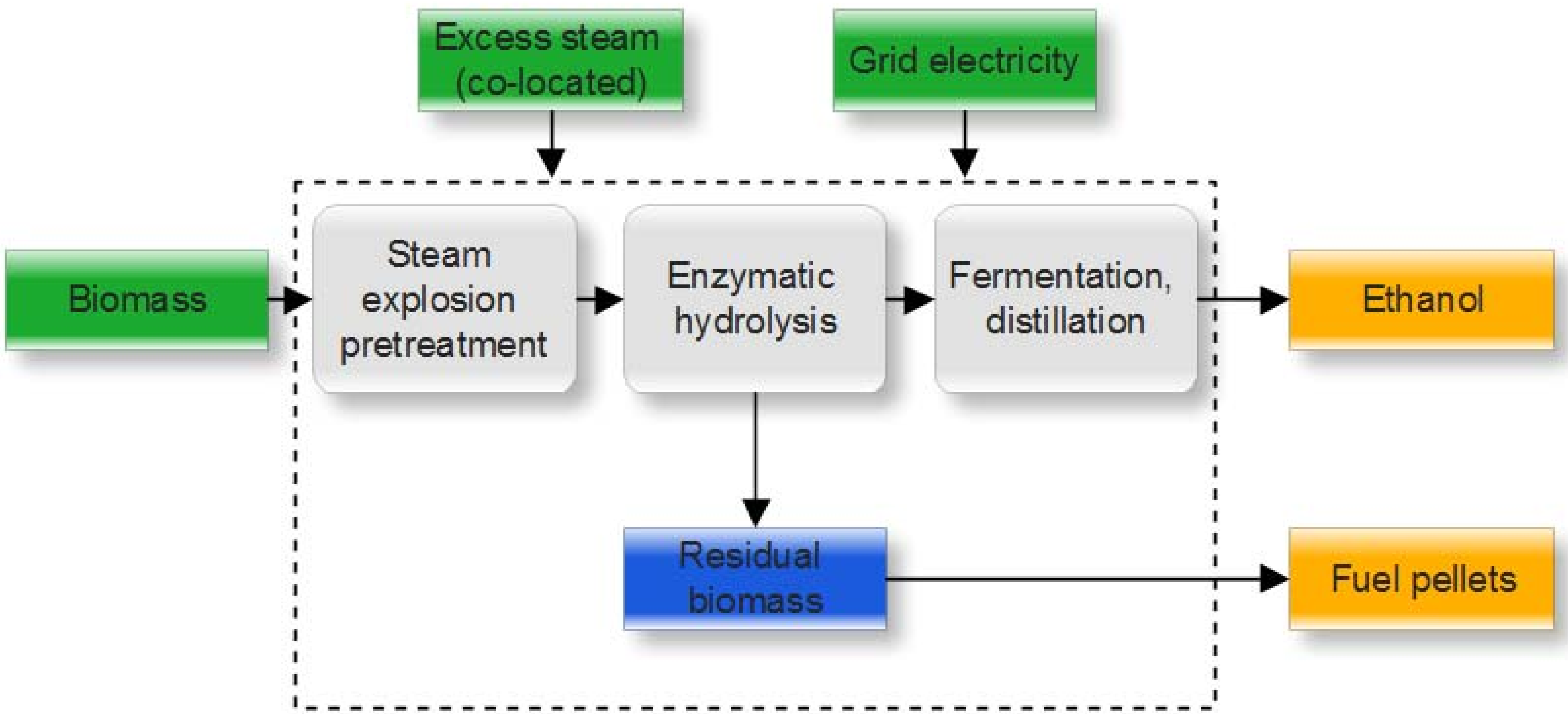
Excess electricity displaces US Midwest grid average

2. Fuel pellet co-product



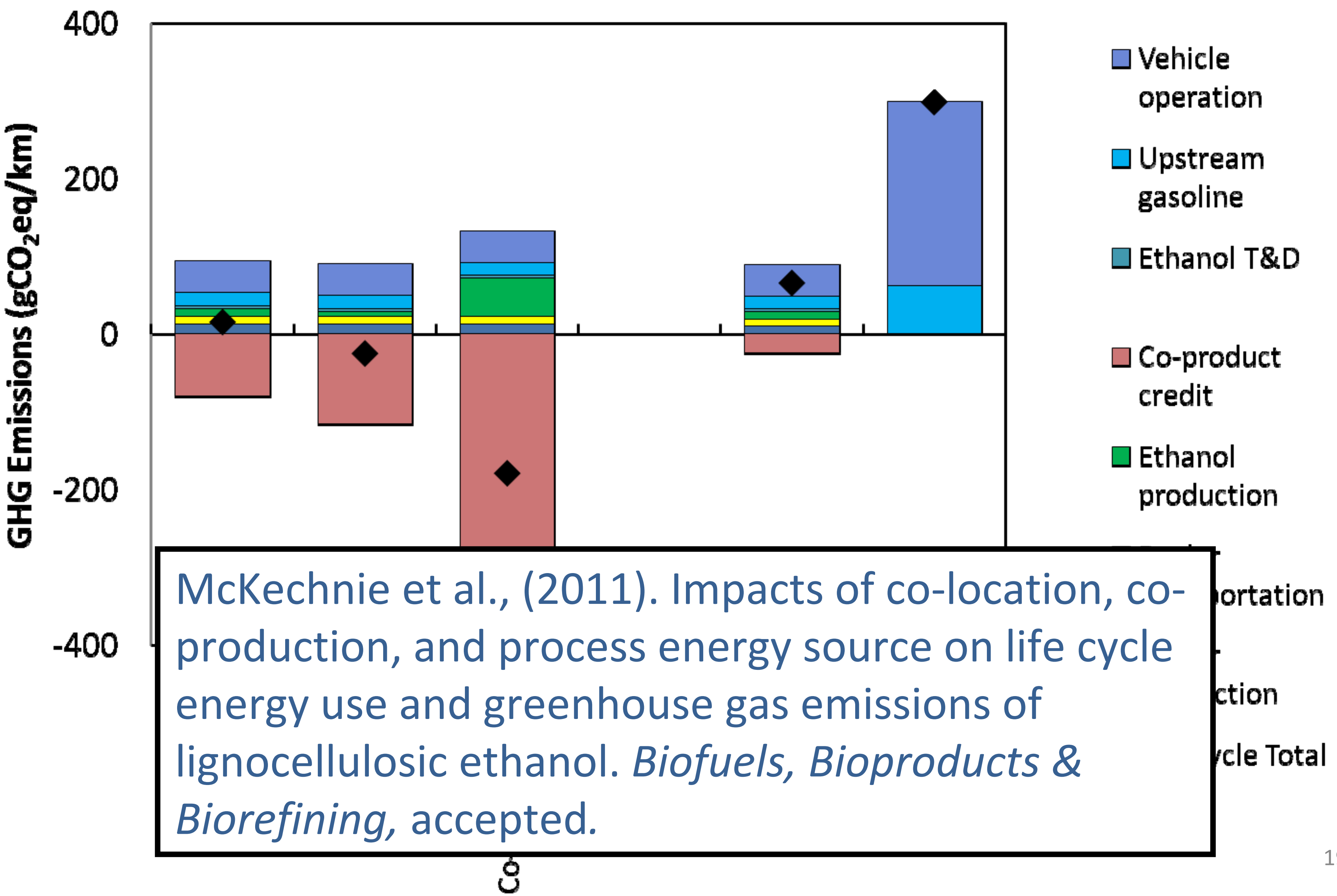
Fuel pellets displace coal in electricity generation

3. Steam input from co-located process, fuel pellet co-product



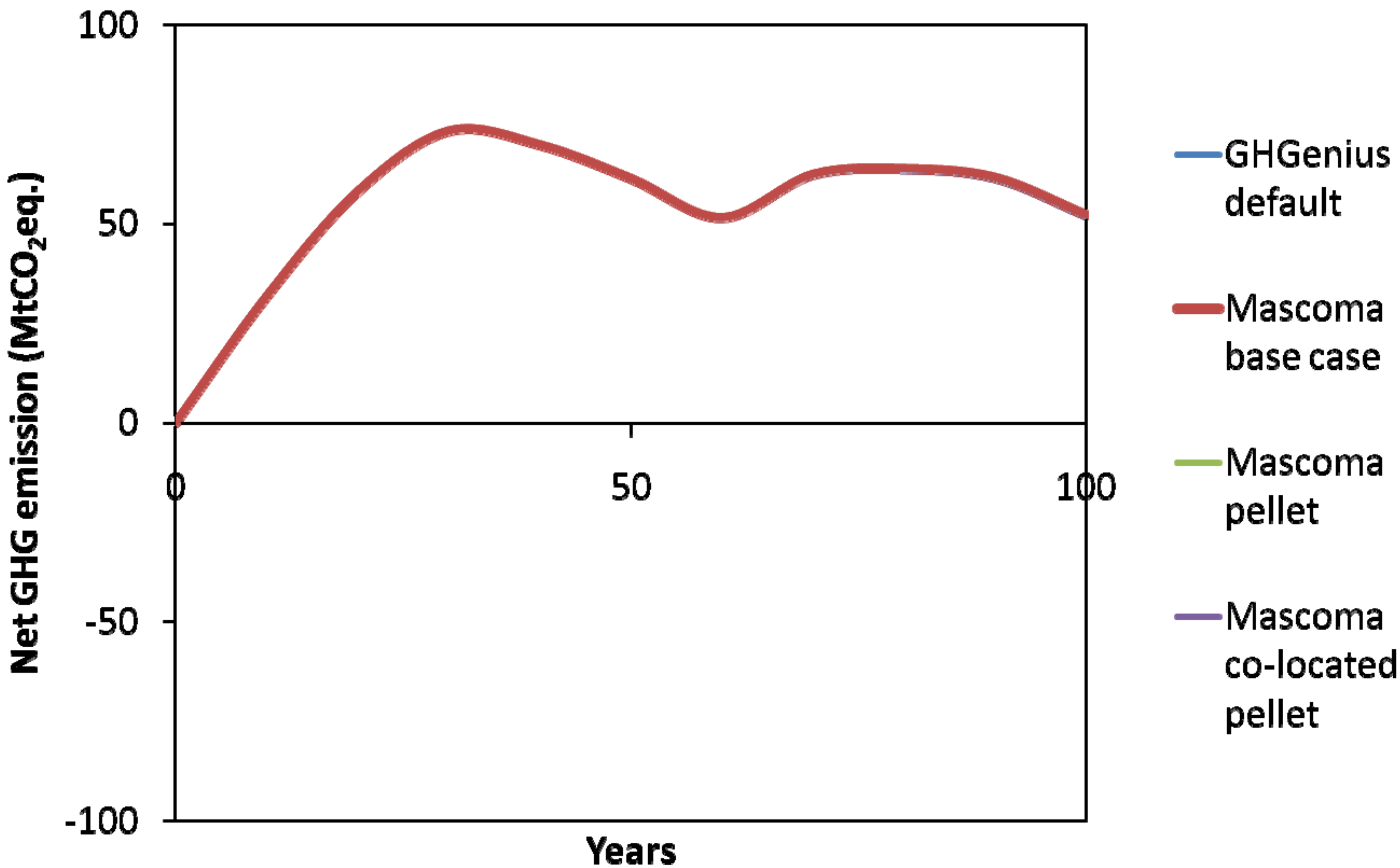
Fuel pellets displace coal in electricity generation

LC GHG emissions results (excluding LUC)



McKechnie et al., (2011). Impacts of co-location, co-production, and process energy source on life cycle energy use and greenhouse gas emissions of lignocellulosic ethanol. *Biofuels, Bioproducts & Biorefining,* accepted.

Applying LC results to GL-SL Region: Total GHG emissions, EtOH from standing trees



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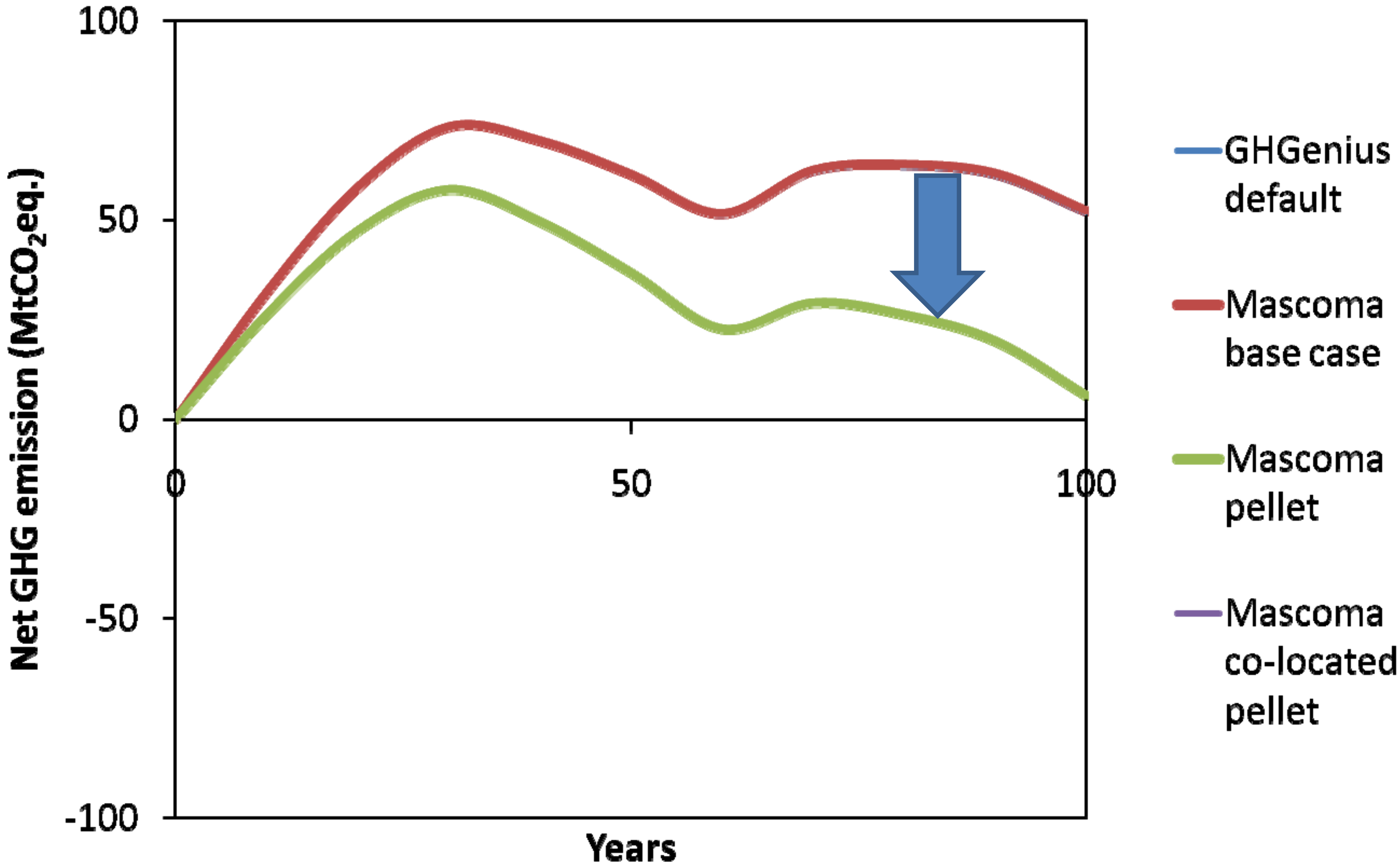

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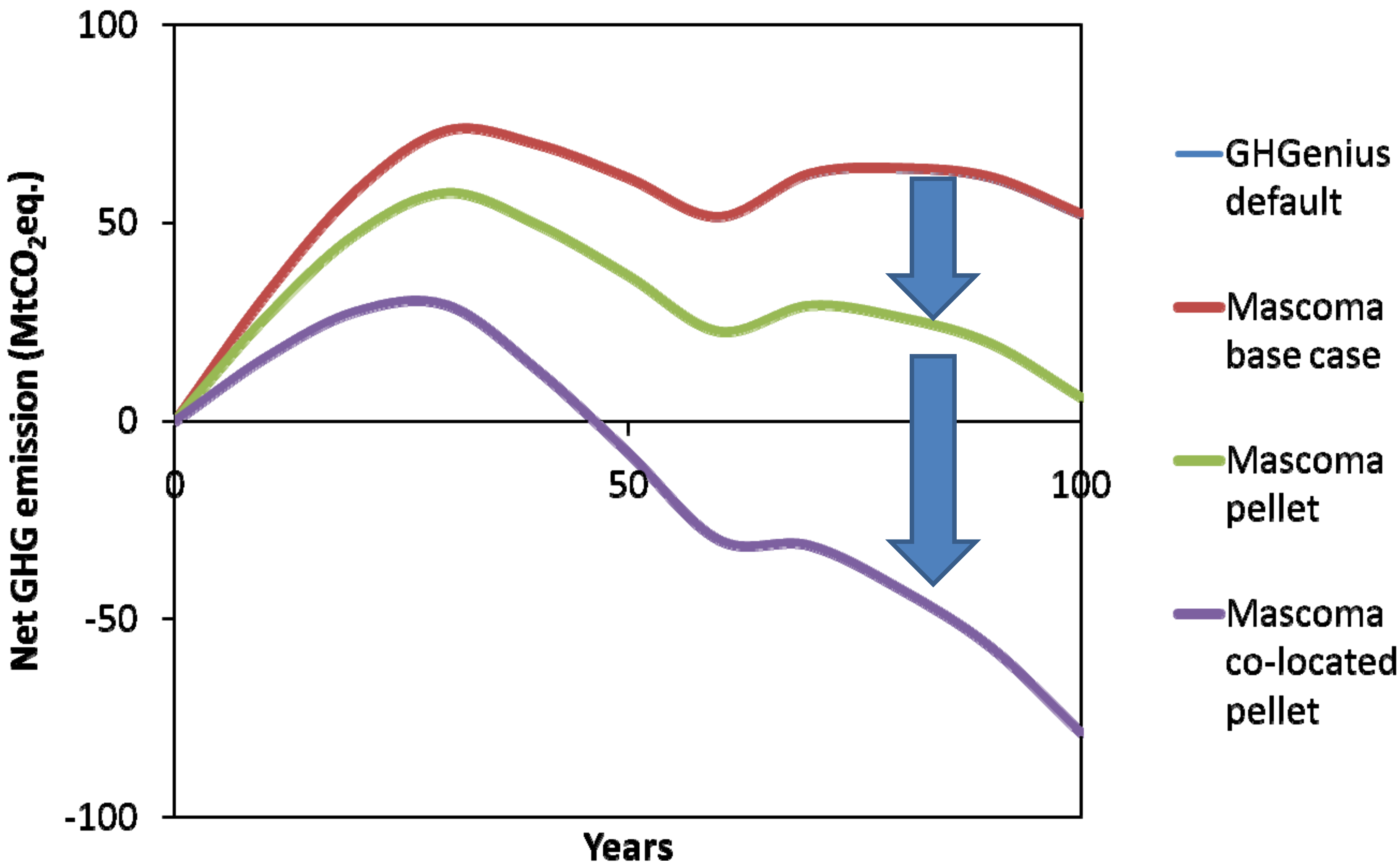
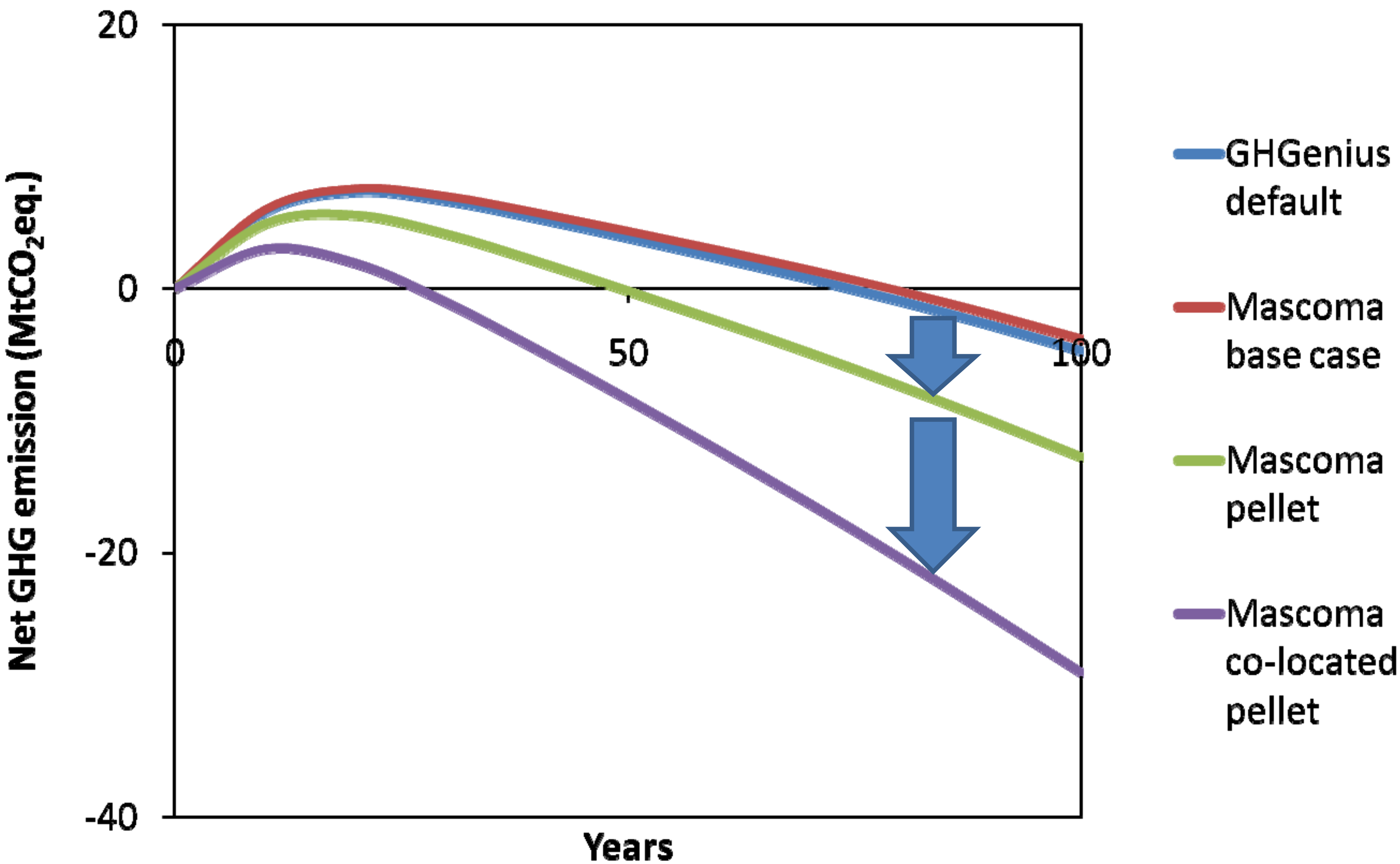


Ethanol from harvest residues



Insights

- Forest carbon impacts are very important
- Timing of GHG benefits is dependent on biomass source (trees vs. residues) and displaced fossil fuel (e.g., coal vs. gasoline)
- Bioenergy production and utilization decisions can significantly affect GHG emissions
- Integration with existing forest products sector or other industrial processes may improve GHG emissions balance
- Forest bioenergy can effectively reduce GHG emissions, but only if it utilizes appropriate biomass sources; targets GHG-intensive fossil fuels