

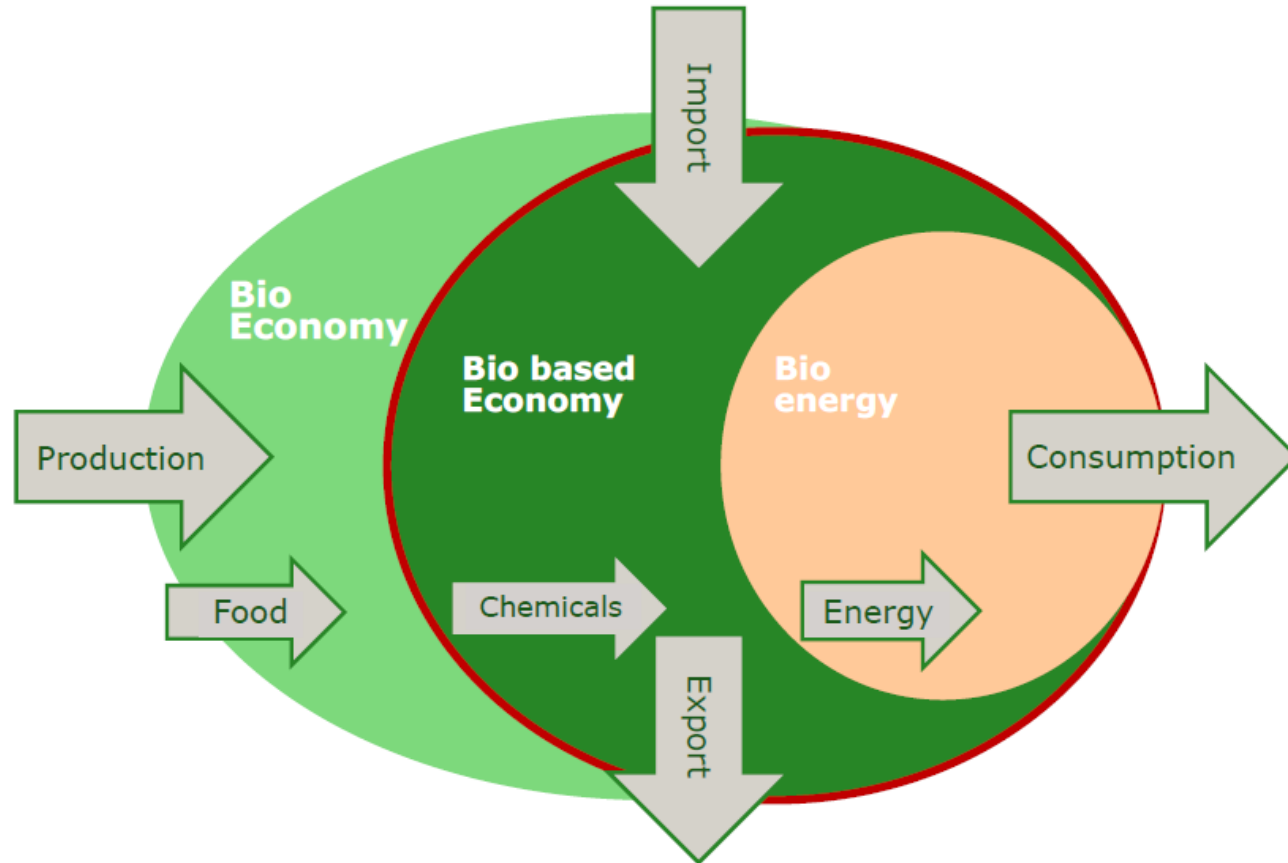
A photograph of a vast green field with a single, large, leafy tree in the center. The sky is bright blue with scattered white clouds. The text is overlaid on the bottom half of the image.

# The Climate Promise of the Bio-Based Economy

**Ernst Worrell**  
**Brussels, September 29<sup>th</sup>, 2015**

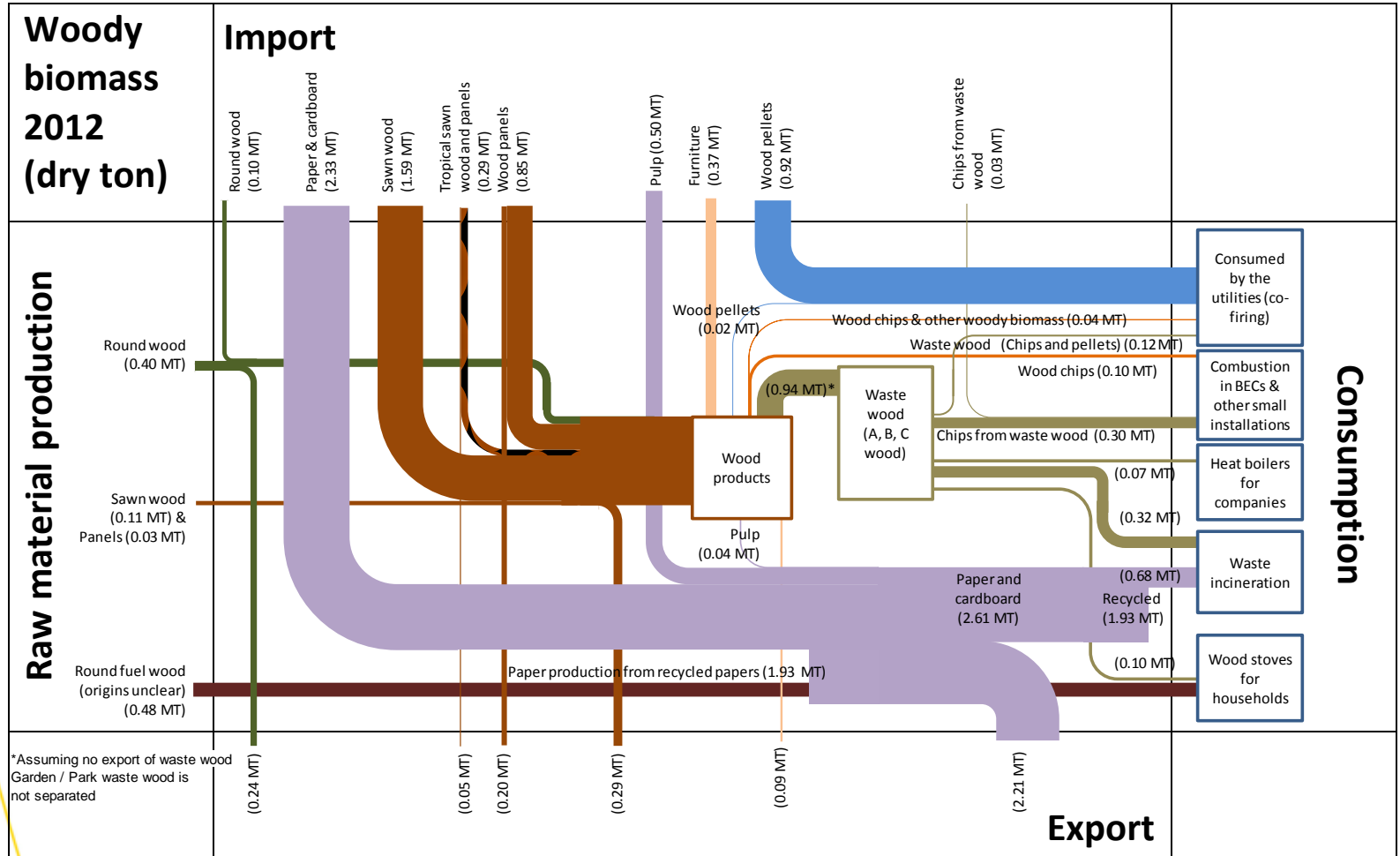


# The Bio-Based Economy





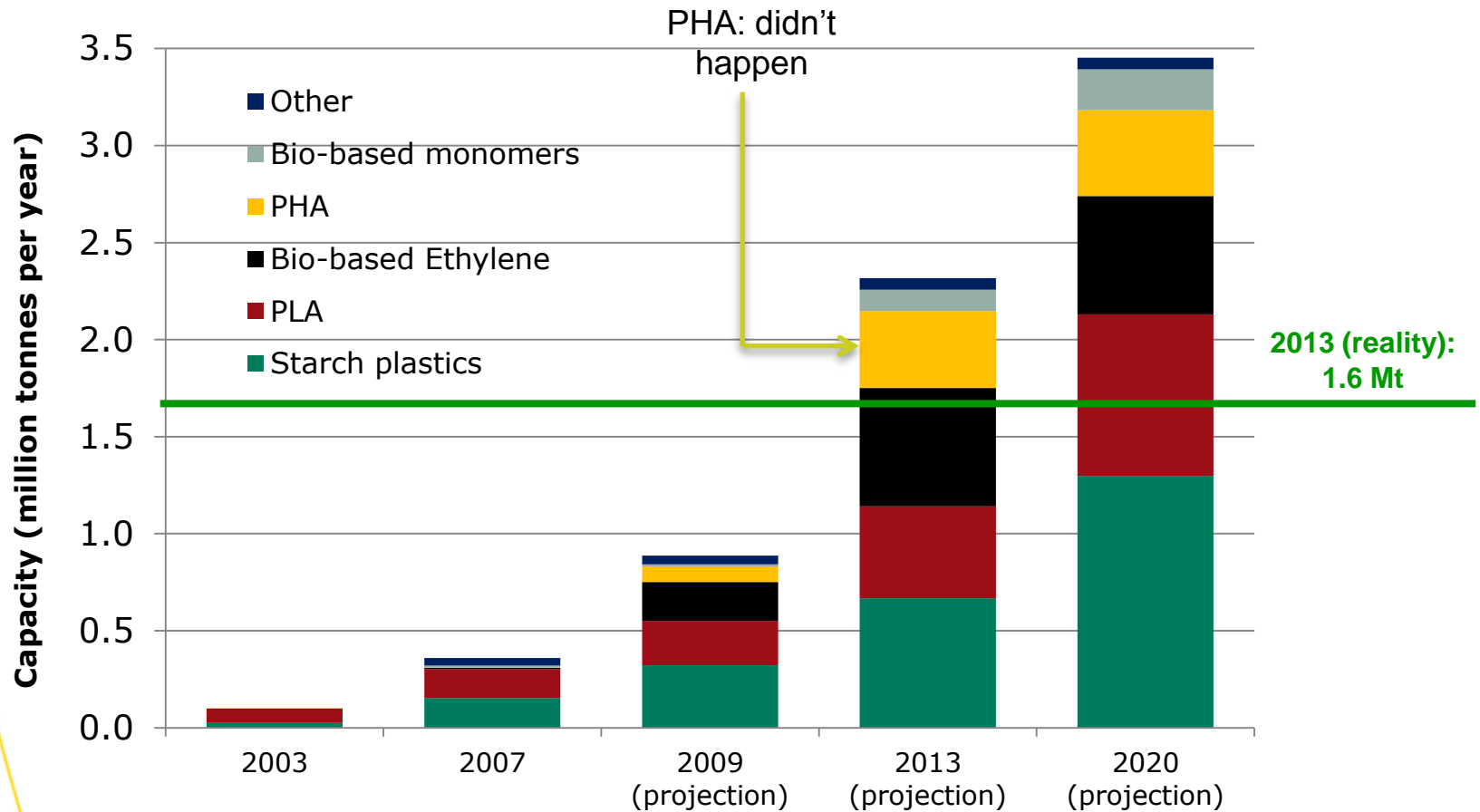
# The Bio-Economy is already here



Source: Goh et al., 2014



# Development with Up's and Down's Global Bioplastics Market

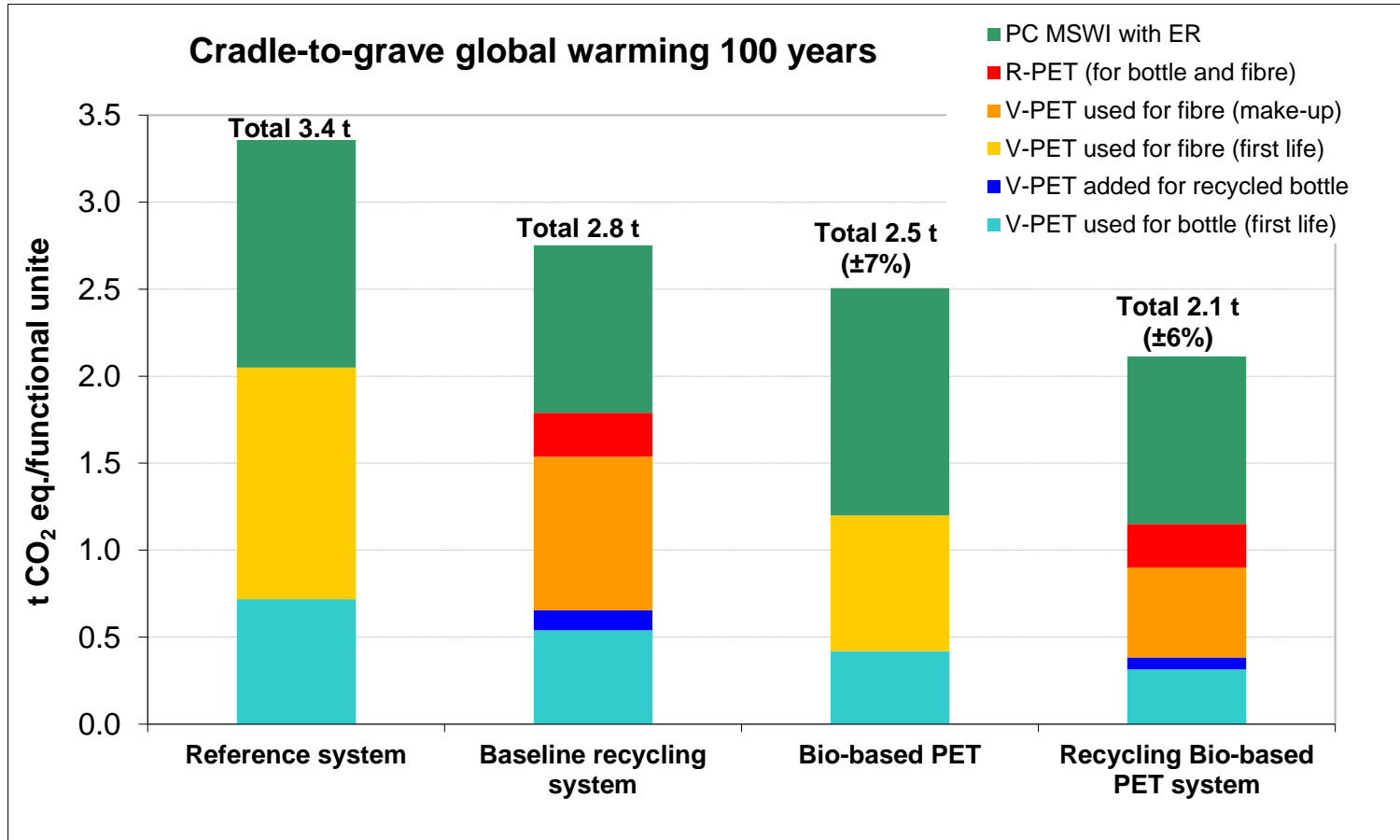


Note: Category "other" includes cellulose films, PTT from bio-based 1,3-PDO, bio-based polyamide and PUR from bio-based polyols; category "Bio-based monomers" includes primarily bio-based epichlorohydrin.

Source: Shen, Worrell & Patel, 2010.



# BBE & Climate Impact: PET



- Functional unit: 350 kg PET bottle + 650 kg PET fibre (representing approximately PET end-use globally).

Source: Shen, Worrell & Patel (2011).



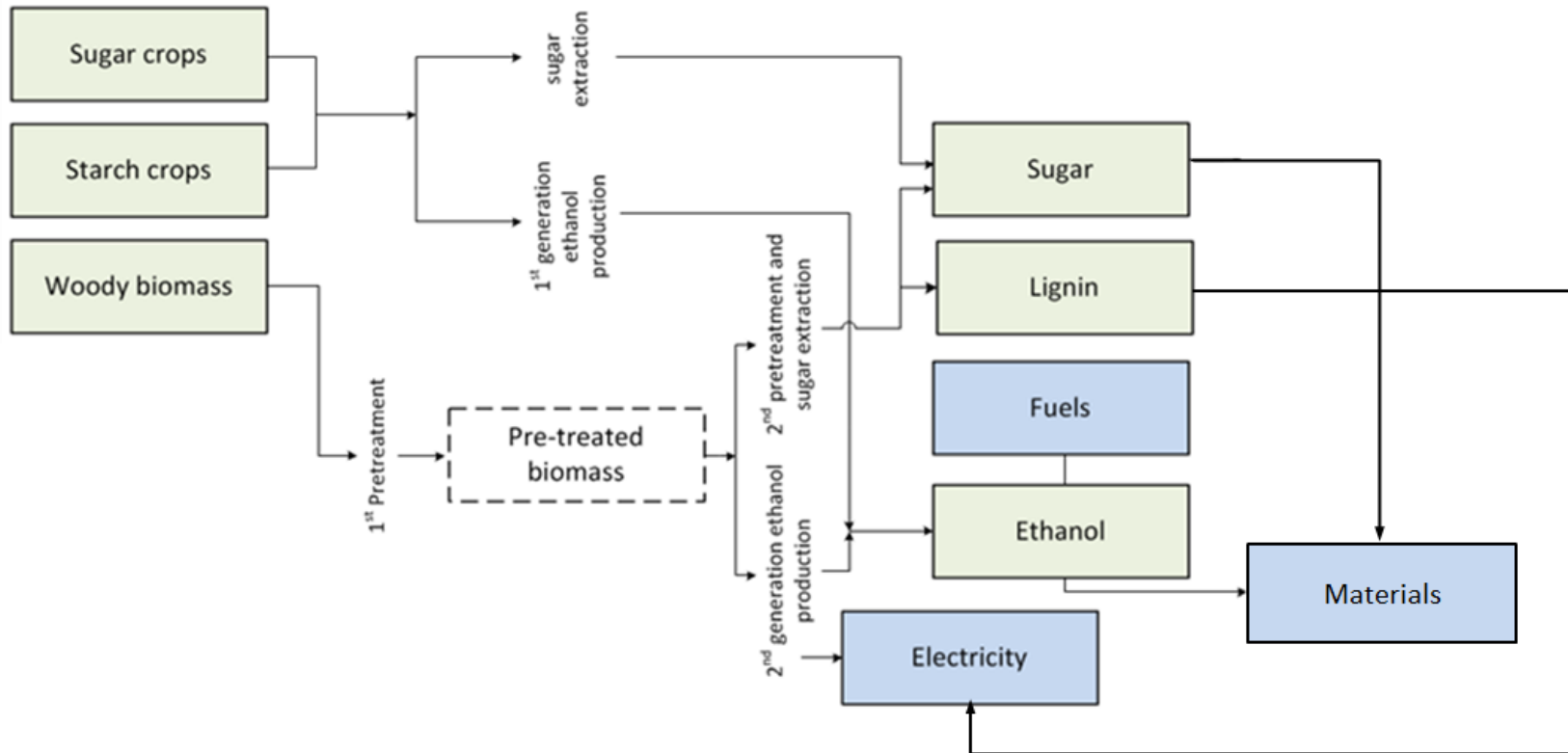
# Climate: Shades of Green

- **Energy efficiency of photo-synthesis is relatively low, making:**
  - Energy-efficient processing important
  - Waste streams the starting point
  - High quality recycling of bio-based product often preferred over use as energy source
- **Bio-based processes are water-based, and water removal is energy intensive**
- **Source and use of energy determines climate impact**
- **Not all bio-based developments are necessary climate-friendly**





# Integrate Chemicals & Energy





# Integration: UPM's Kaukas mill: pulp, paper, chemicals, energy

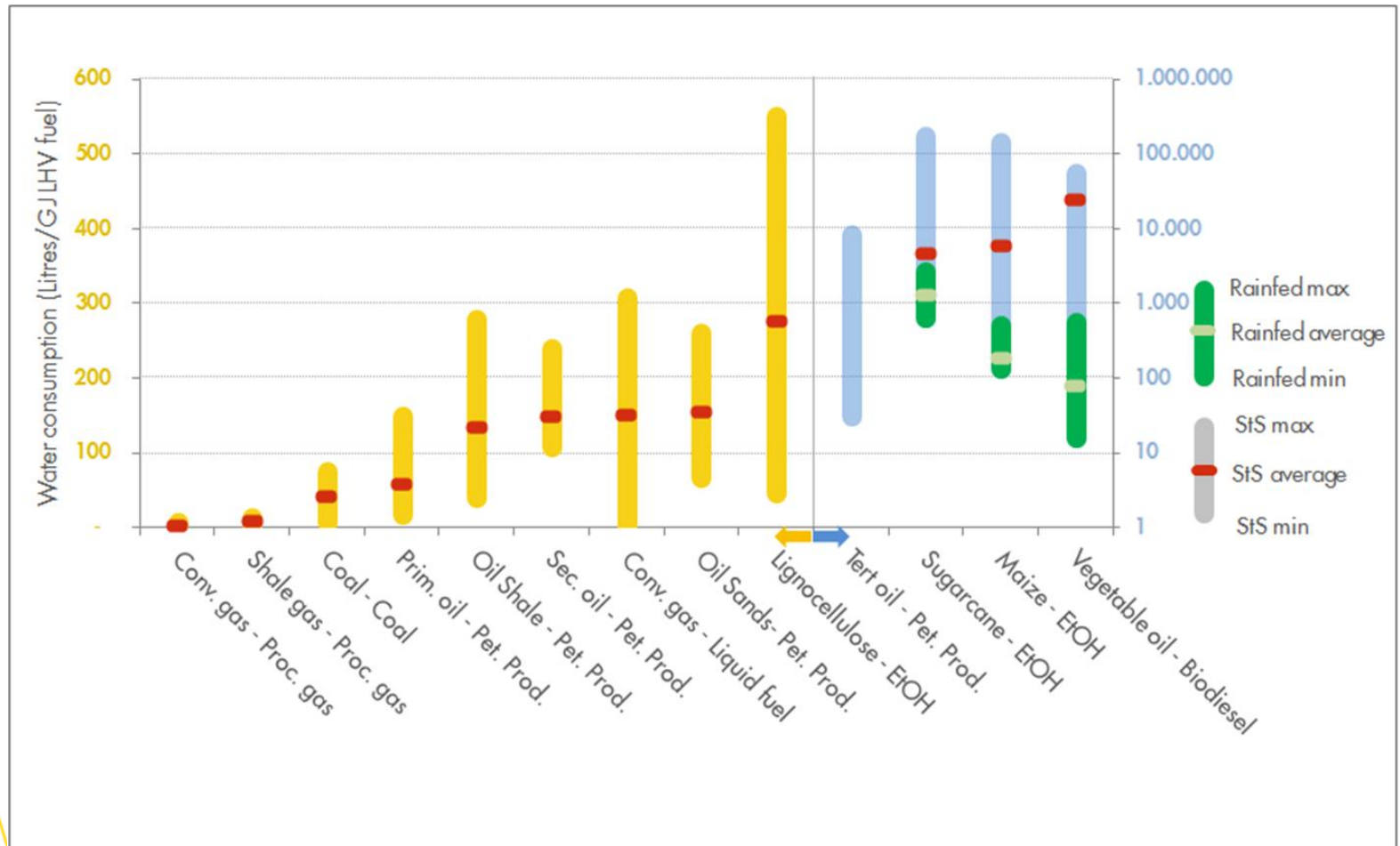


Photo: Tuomas Vitikainen





# Biomass Sourcing is Key Alternative Fuels & Freshwater Withdrawals



Source: Schornagel et al., 2012



# Concluding

- Bio-Based Economy is here!
- The role of emerging sectors of the bio-based economy could be substantial
- Bio-based economy contributes to climate change mitigation and is part of the menu
- It is no *Deus ex Machina* to mitigate CO<sub>2</sub> emissions
- Identify those biomass sources, applications, and processes that have positive impact
- Bio-economy requires an integrated systems perspective to realize benefits



# Thank you for your attention

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