



# How much biomass are we talking about?

## Bio-energy futures envisioned by Integrated Assessment Modeling

**Steven Rose**

*Energy Modeling Forum: Workshop on Climate  
Change Impacts and Integrated Assessment,  
Snowmass, CO*

July 27, 2011

# Bioenergy and climate management

- Bioenergy in the energy transformation required for managing climate?
- How important is bioenergy?

# Outline

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- Initial observations
- Coordinated deeper dive (on-going)



# Initial observations

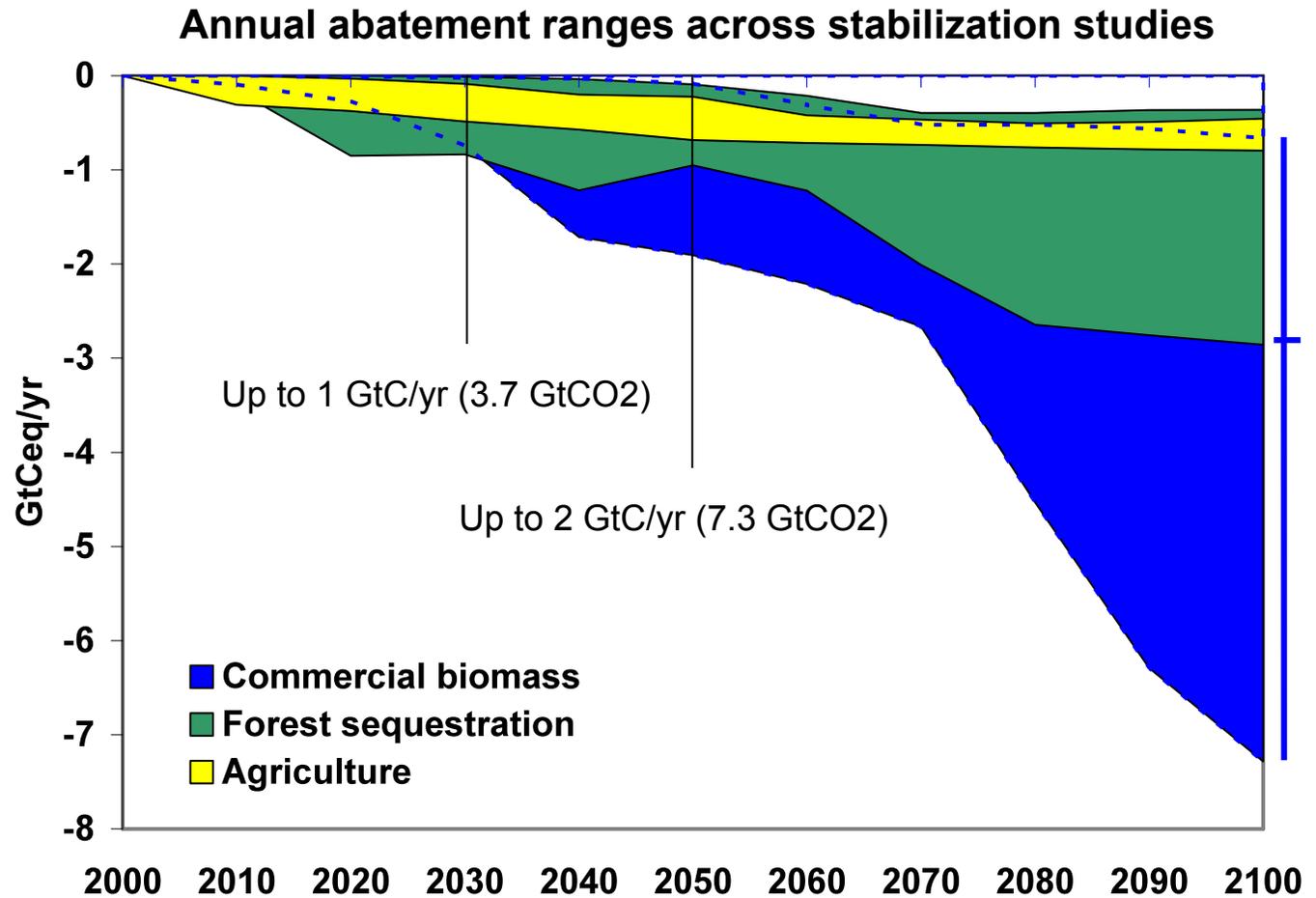
# Bioenergy and climate stabilization?

Cumulative biomass share (of Total)

2000-2030: 2 – 26%

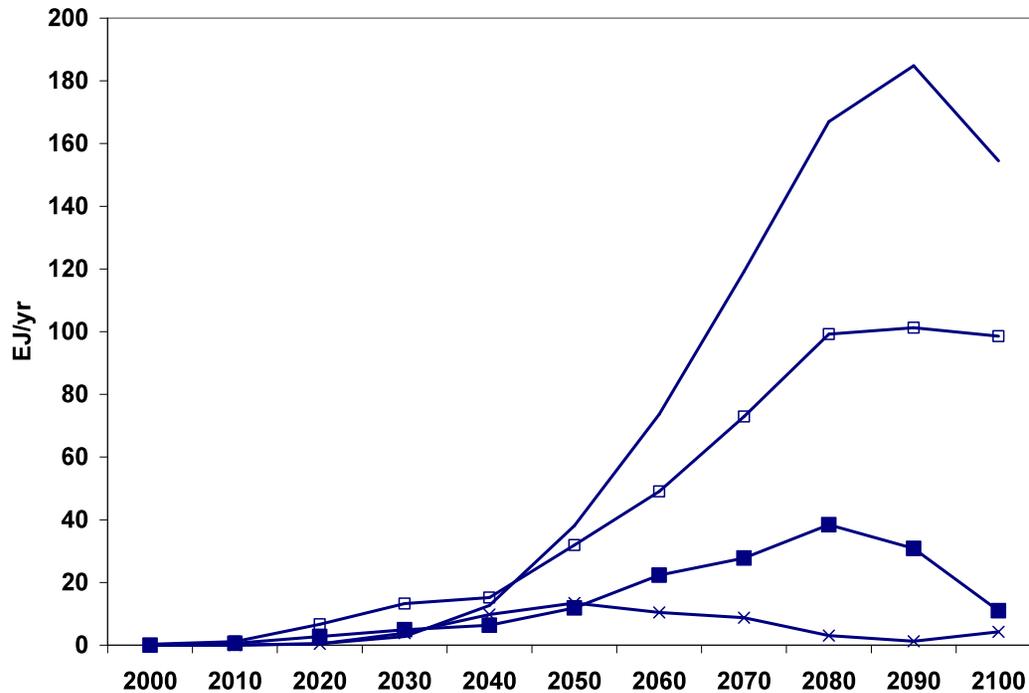
2000-2050: 4 – 31%

2000-2100: 5 – 29%

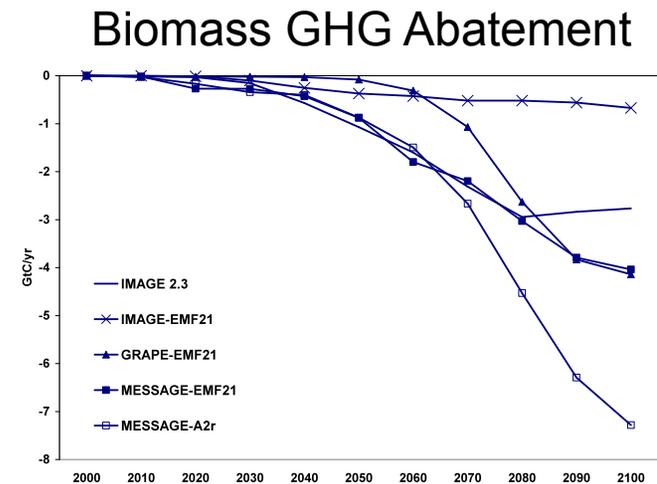


*Rose et al. (in press)*

# Bioenergy and climate stabilization?



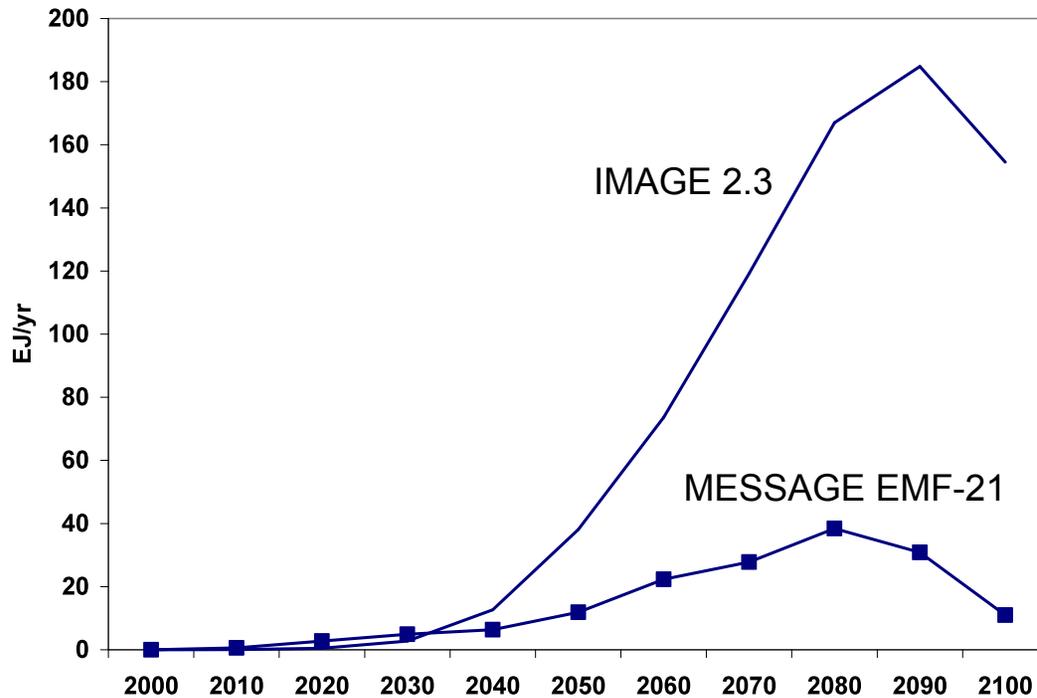
Biomass Primary Energy for 4.5 W/m2 stabilization scenarios



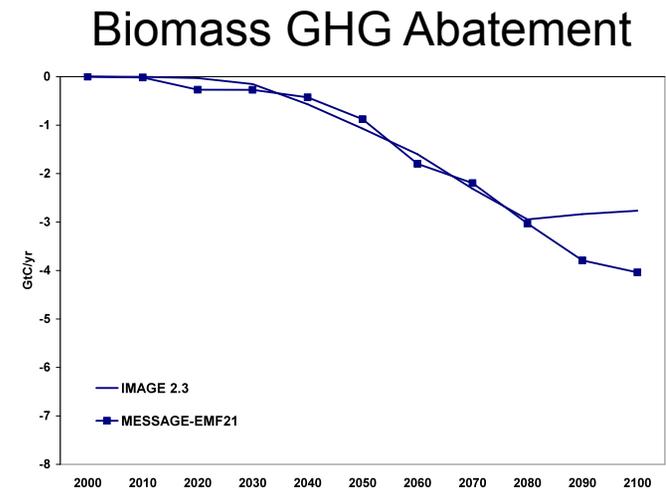
Biomass GHG Abatement

Rose et al. (in press)

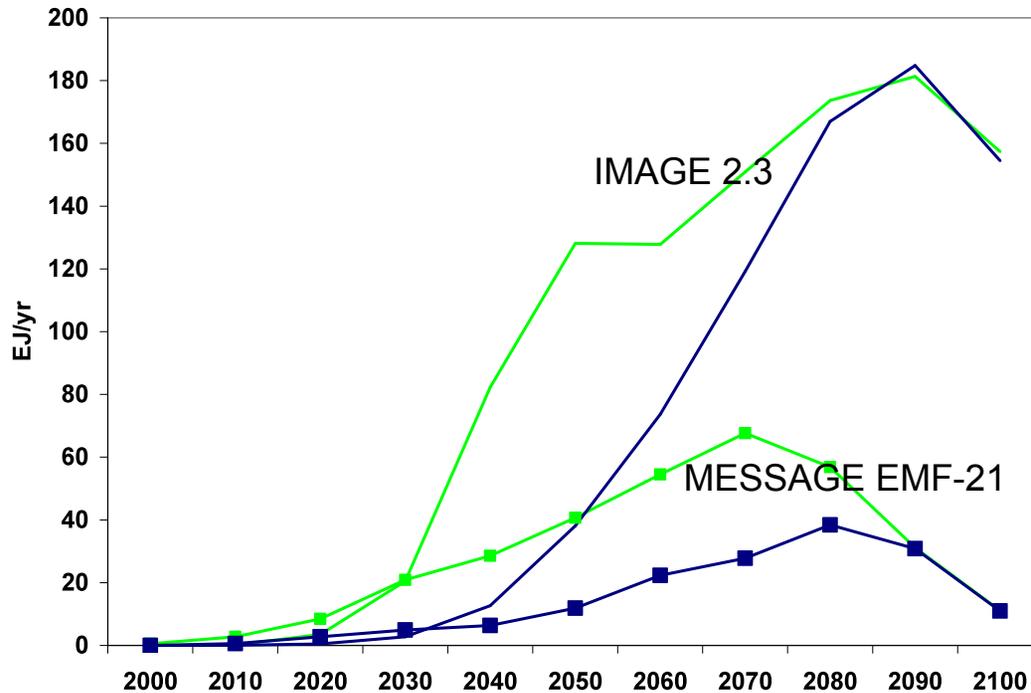
# Bioenergy and climate stabilization?



Biomass Primary Energy for 4.5 W/m2 stabilization scenarios

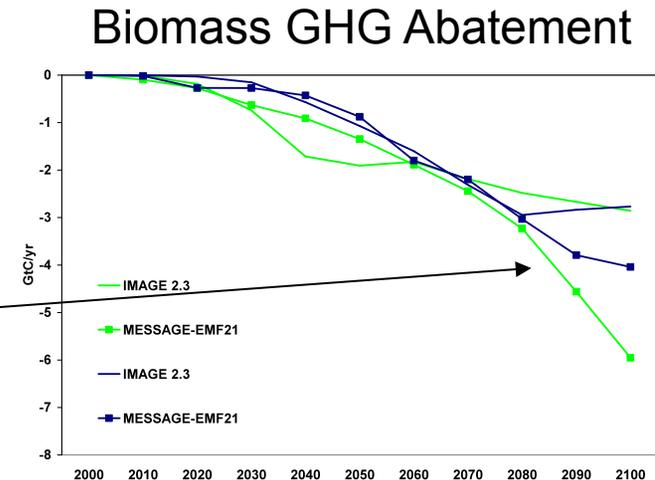


# Bioenergy and climate stabilization?



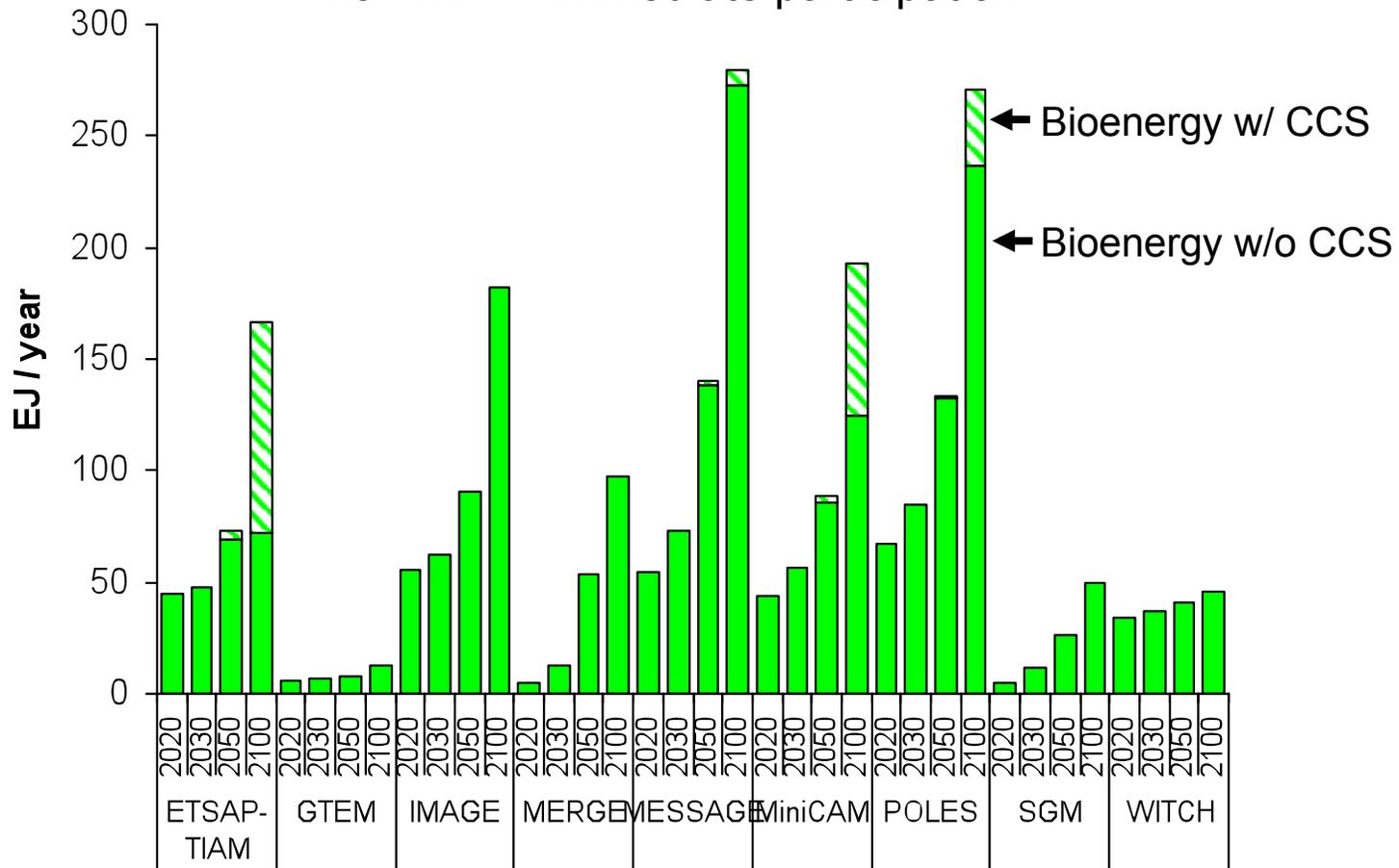
Biomass Primary Energy for 4.5 (blue) & 3 (green) W/m<sup>2</sup> stabilization scenarios

MESSAGE 2050-2100 BioCCS  
 73% of bioenergy GHG abatement  
 14% of total abatement



# Bioenergy with CCS – How Important?

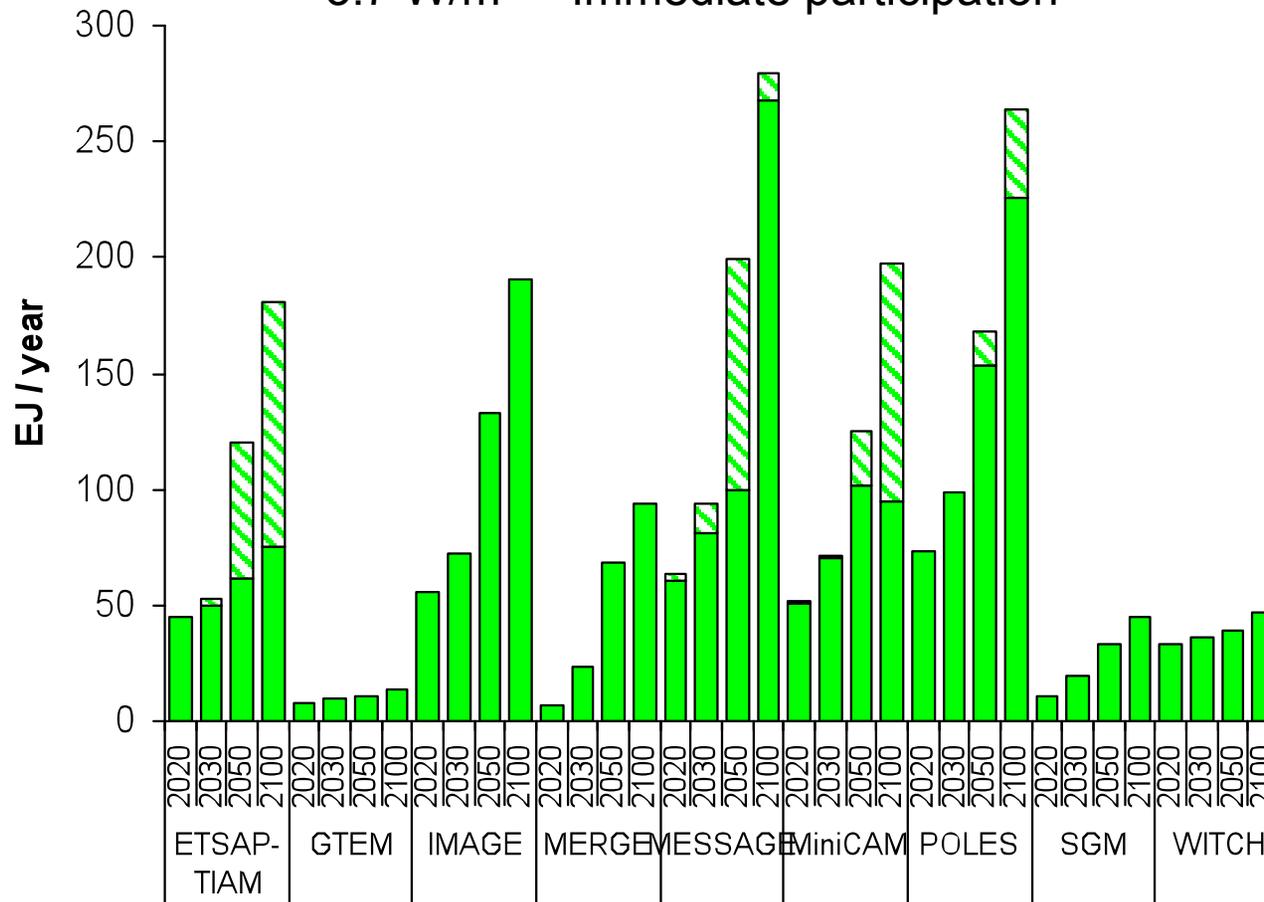
4.5 W/m<sup>2</sup> – Immediate participation



Derived from Clarke et al. (2009)

# Bioenergy with CCS – How Important?

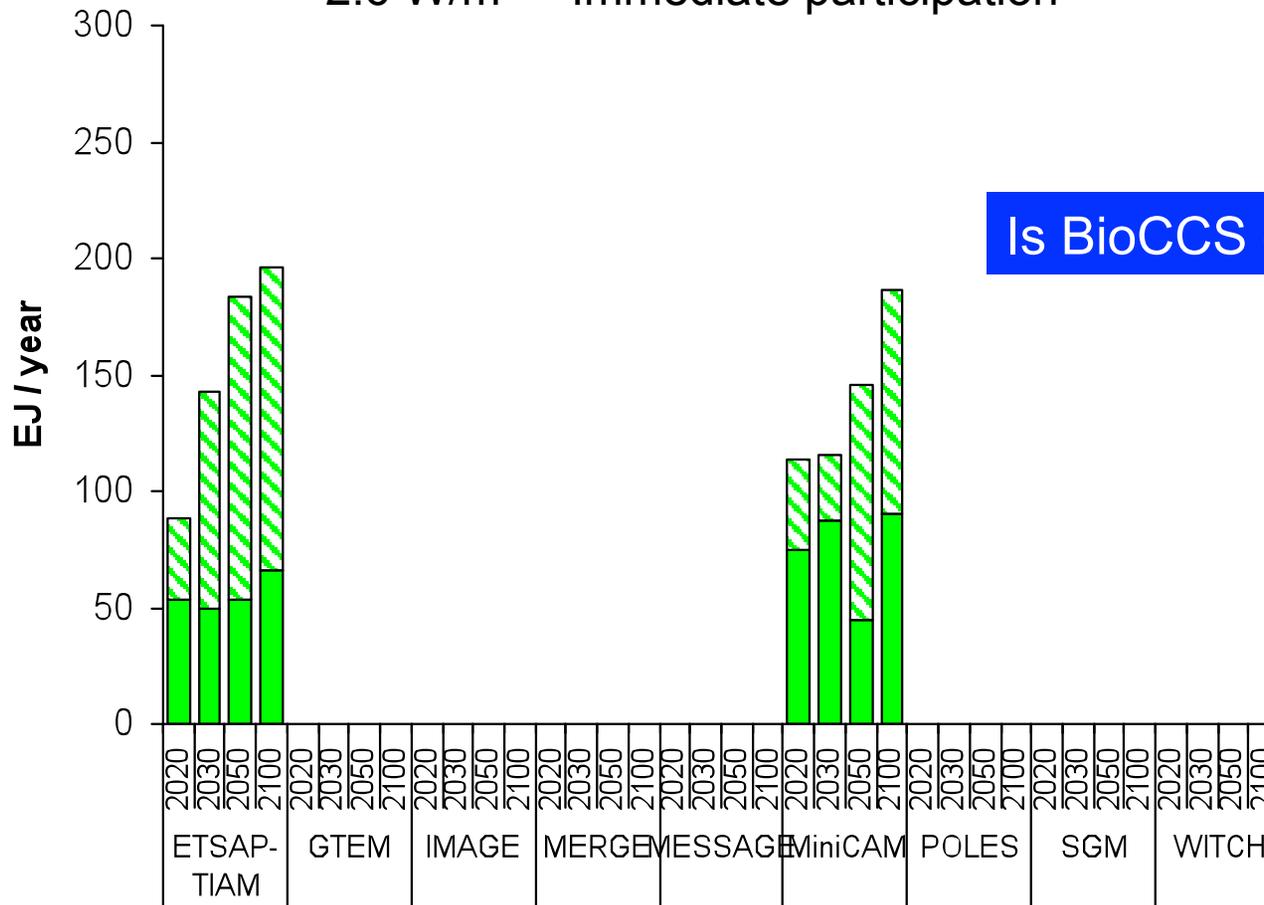
3.7 W/m<sup>2</sup> – Immediate participation



Derived from Clarke et al. (2009)

# Bioenergy with CCS – How Important?

2.6 W/m<sup>2</sup> – Immediate participation

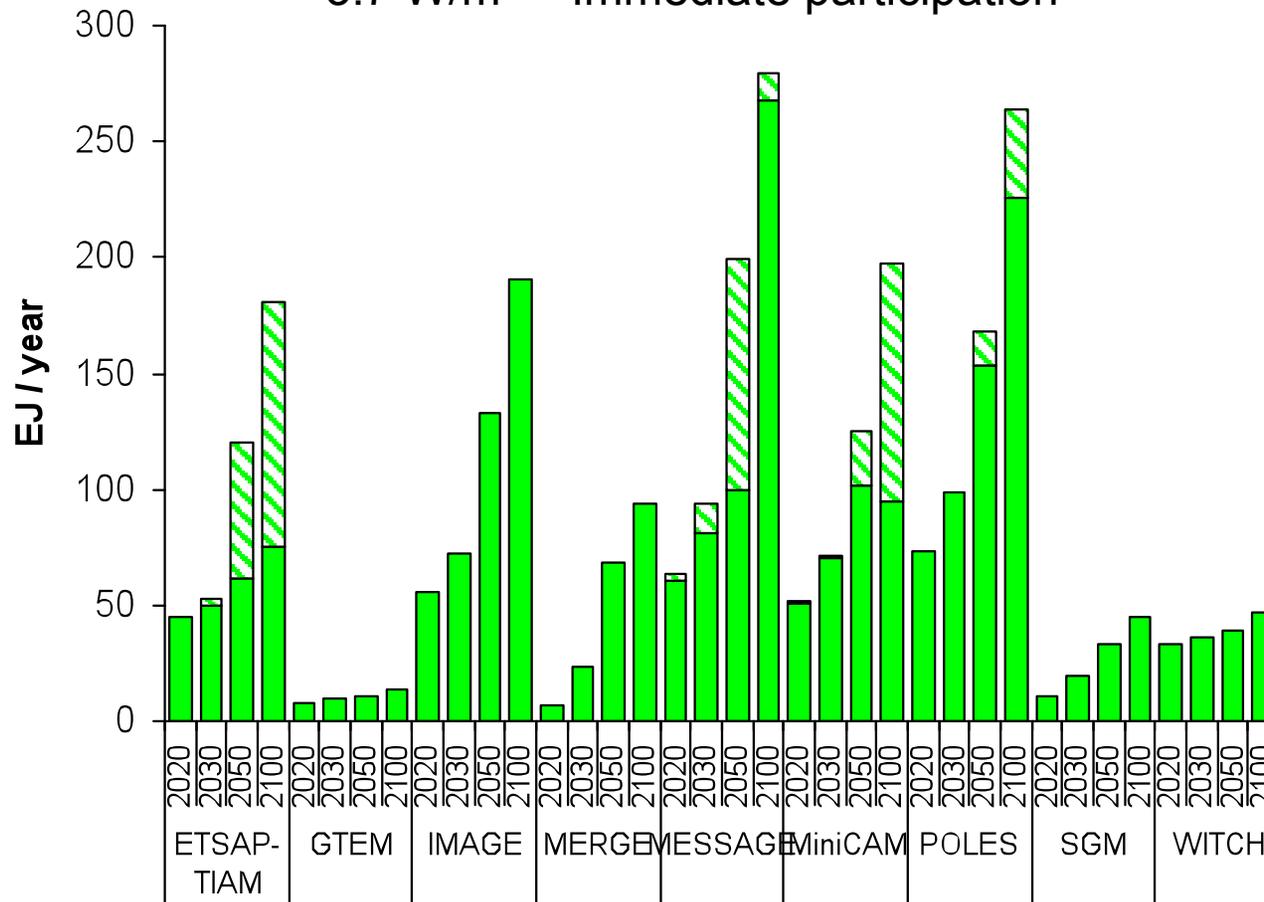


Is BioCCS essential?

Derived from Clarke et al. (2009)

# Bioenergy with CCS – How Important?

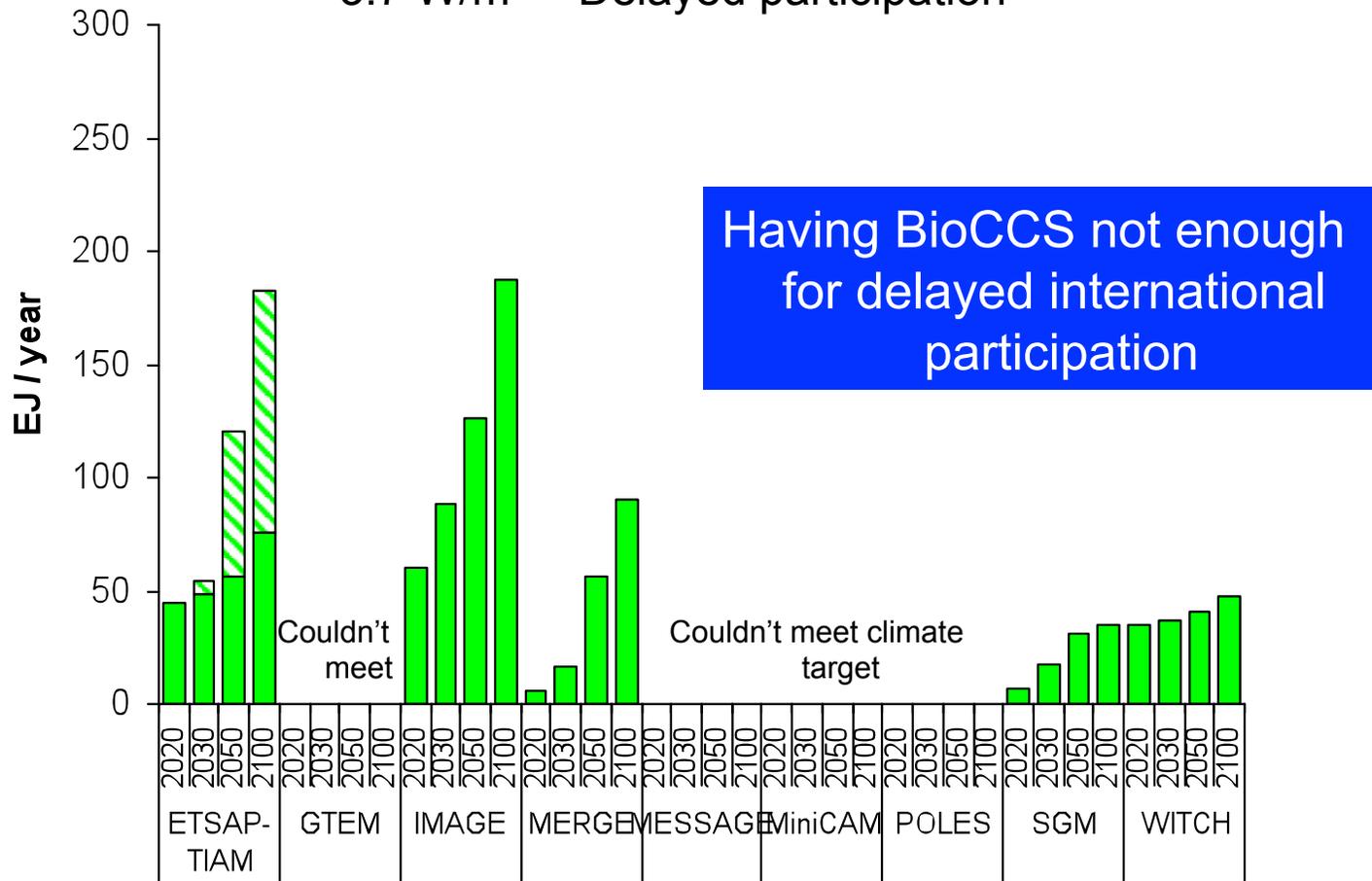
3.7 W/m<sup>2</sup> – Immediate participation



Derived from Clarke et al. (2009)

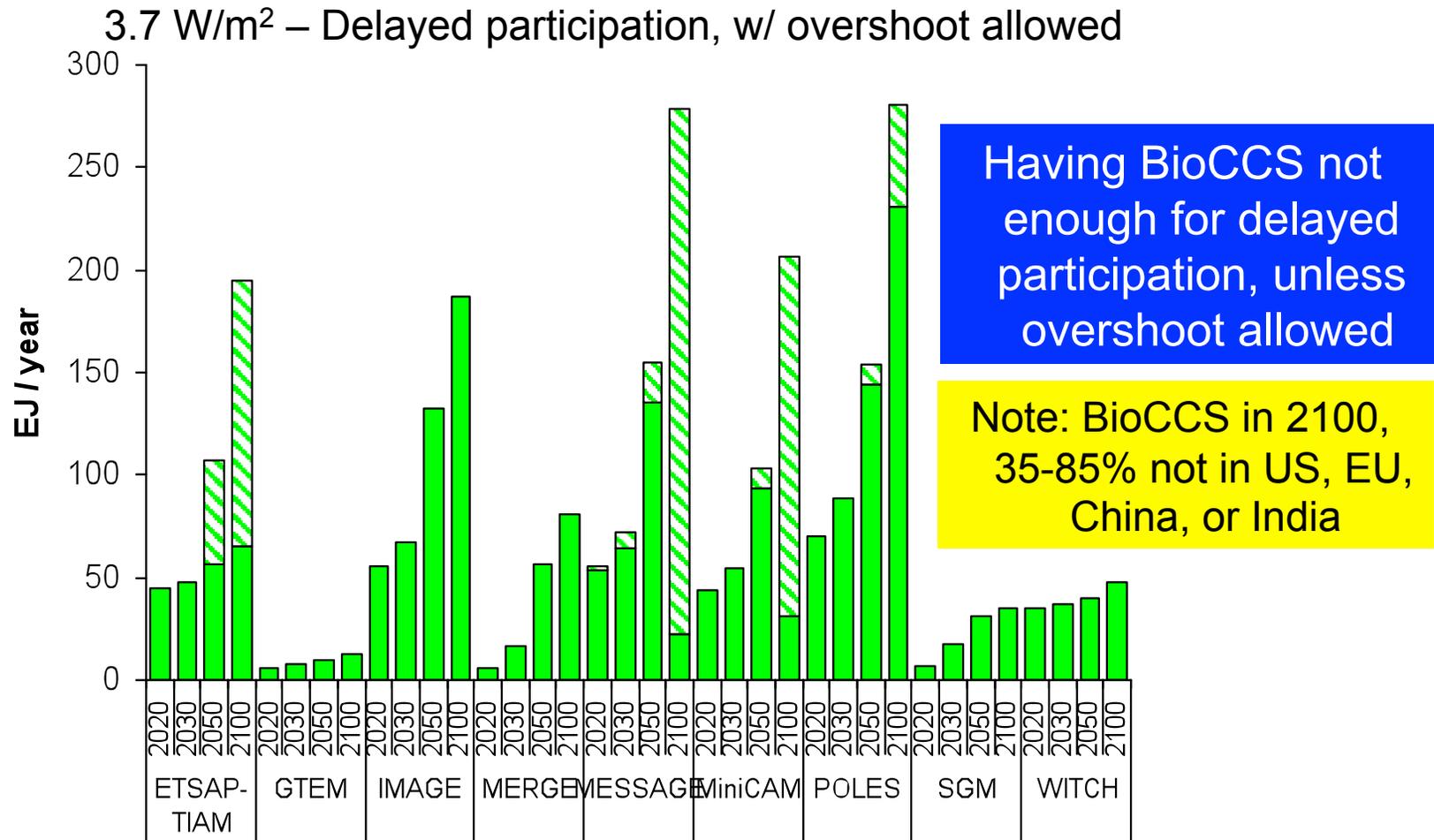
# Bioenergy with CCS – How Important?

3.7 W/m<sup>2</sup> – Delayed participation



Derived from Clarke et al. (2009)

# Bioenergy with CCS – How Important?



Derived from Clarke et al. (2009)



# Coordinated deeper dive into current modeling (on-going)

***Results not for citation  
For stimulating Snowmass discussion***

# Contributors

- Elmar Kriegler
- Jae Edmonds
- Detlef van Vuuren
- John Weyant
- Gunnar Luderer

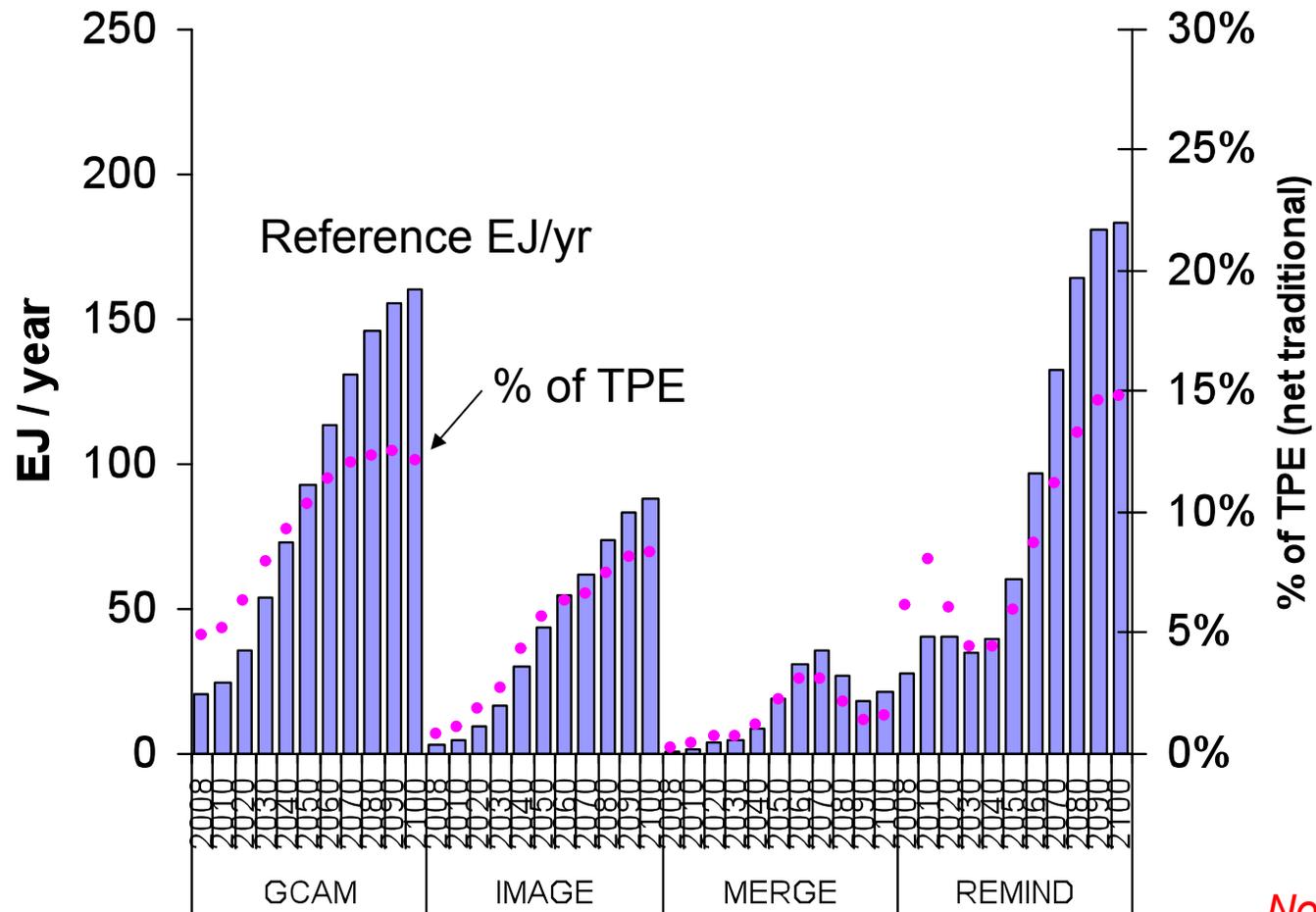
## EMF-24 bioenergy subgroup

- Characterize and assess current bioenergy modeling details and the potential role of bioenergy in the future
- Assess the role of bioenergy in the achievement of 450 ppm CO<sub>2</sub>e stabilization

# Subgroup models to date

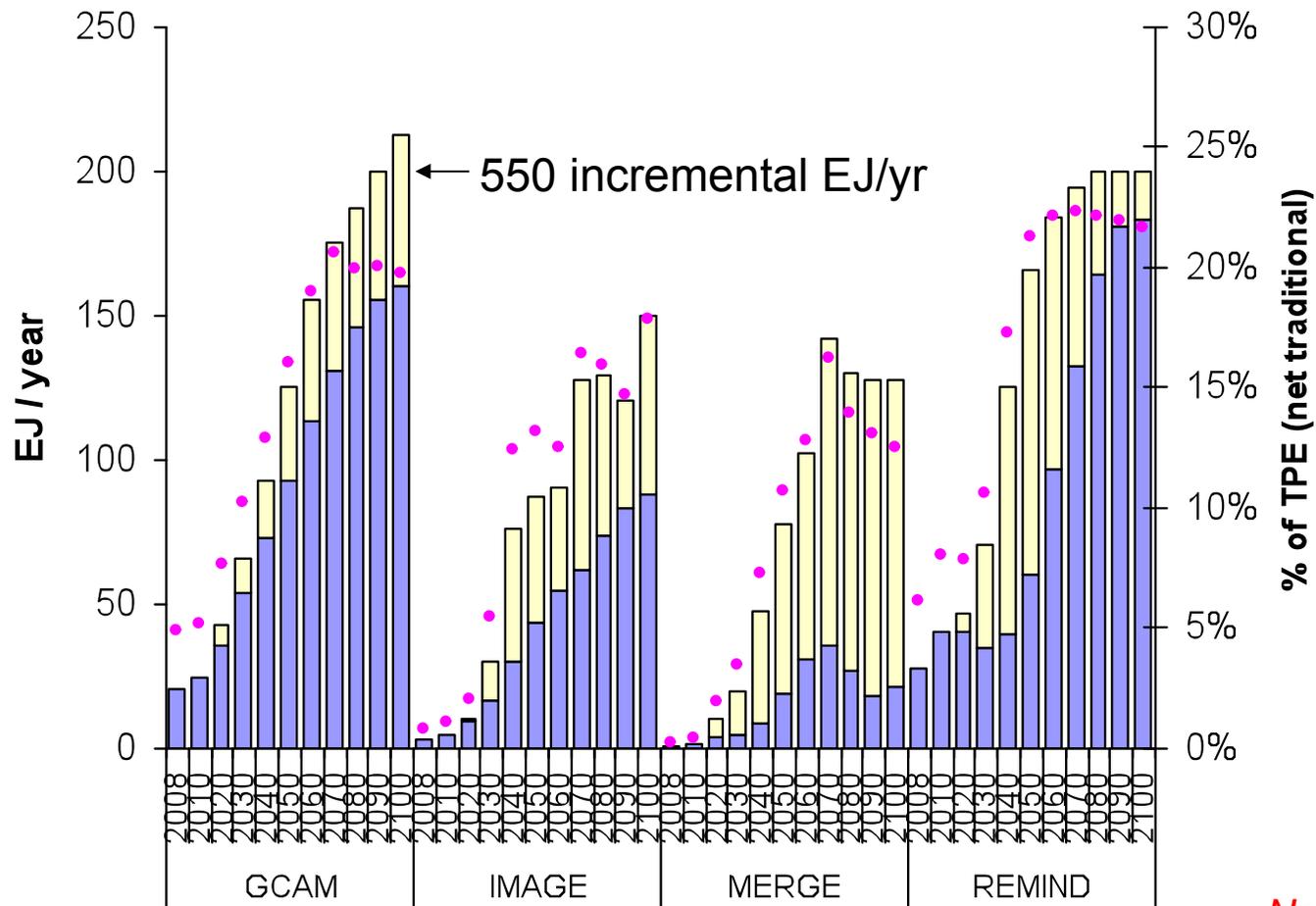
- GCAM (PNNL)
- IMAGE (PBL)
- MERGE (EPRI)
- REMIND (PIK)

# Biomass primary energy – reference (net traditional bioenergy)



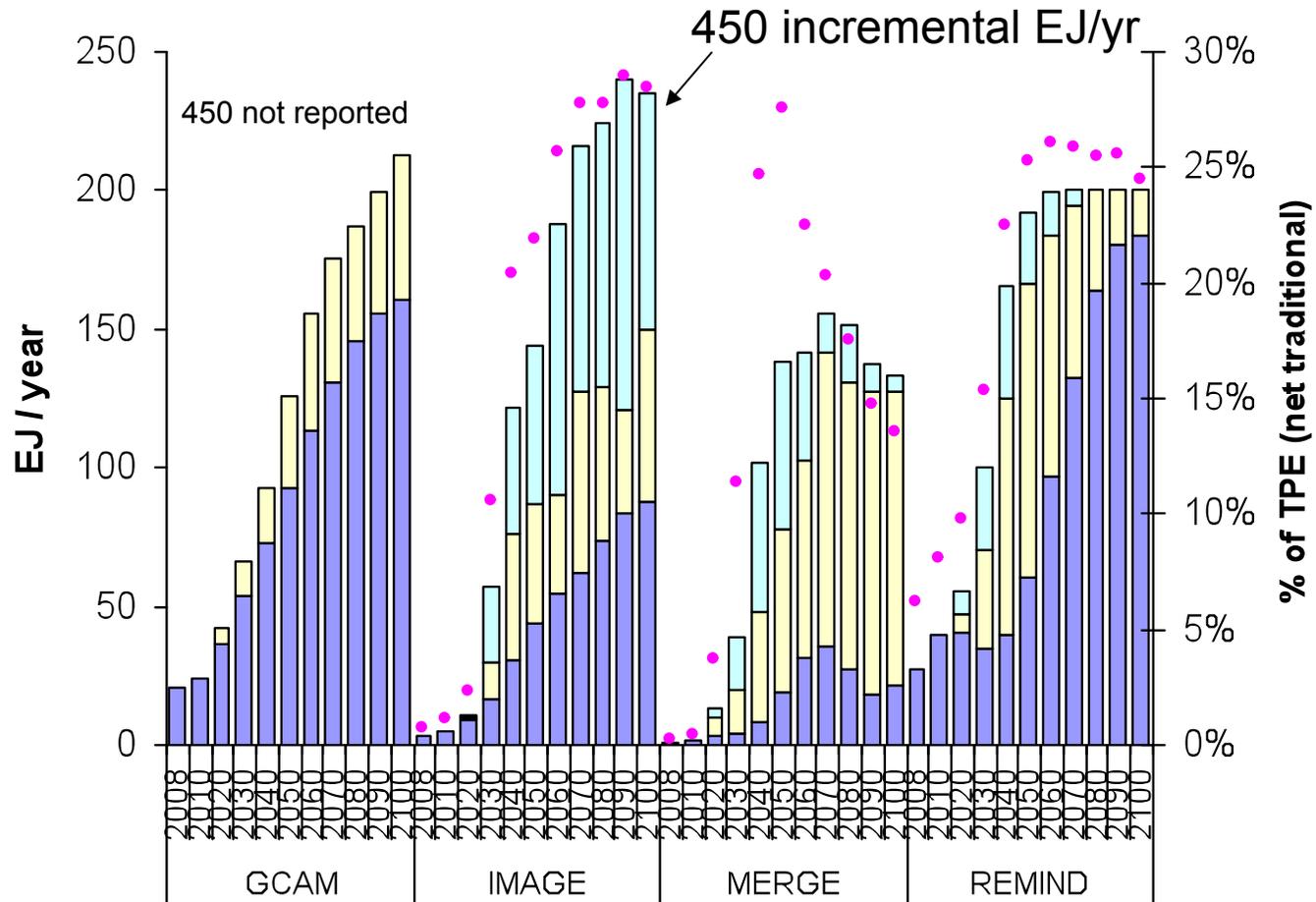
*Not for citation*

# Biomass primary energy – 550 ppm policy (net traditional bioenergy)



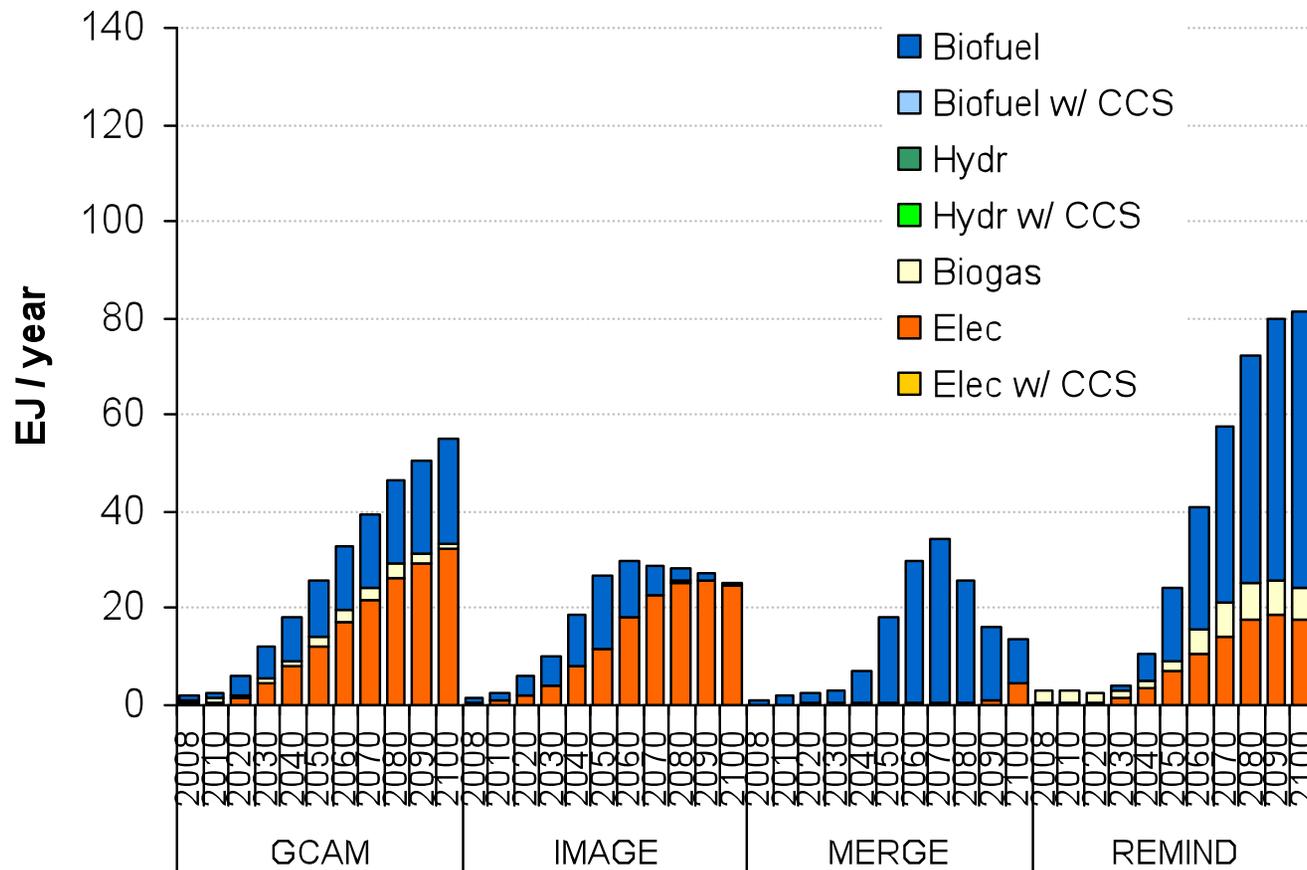
*Not for citation*

# Biomass primary energy – 450 ppm policy (net traditional bioenergy)



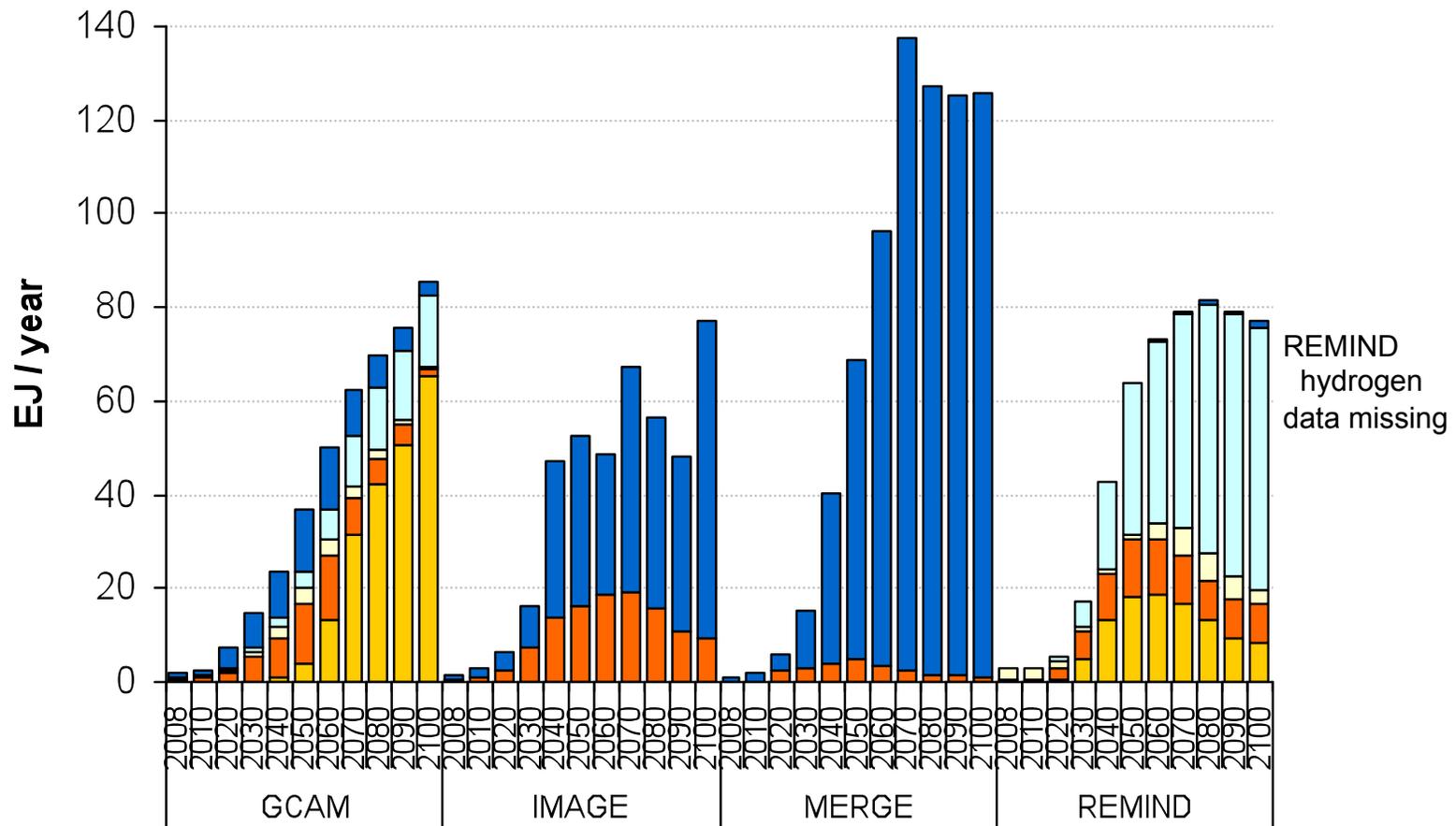
*Not for citation*

# Biomass secondary energy – reference



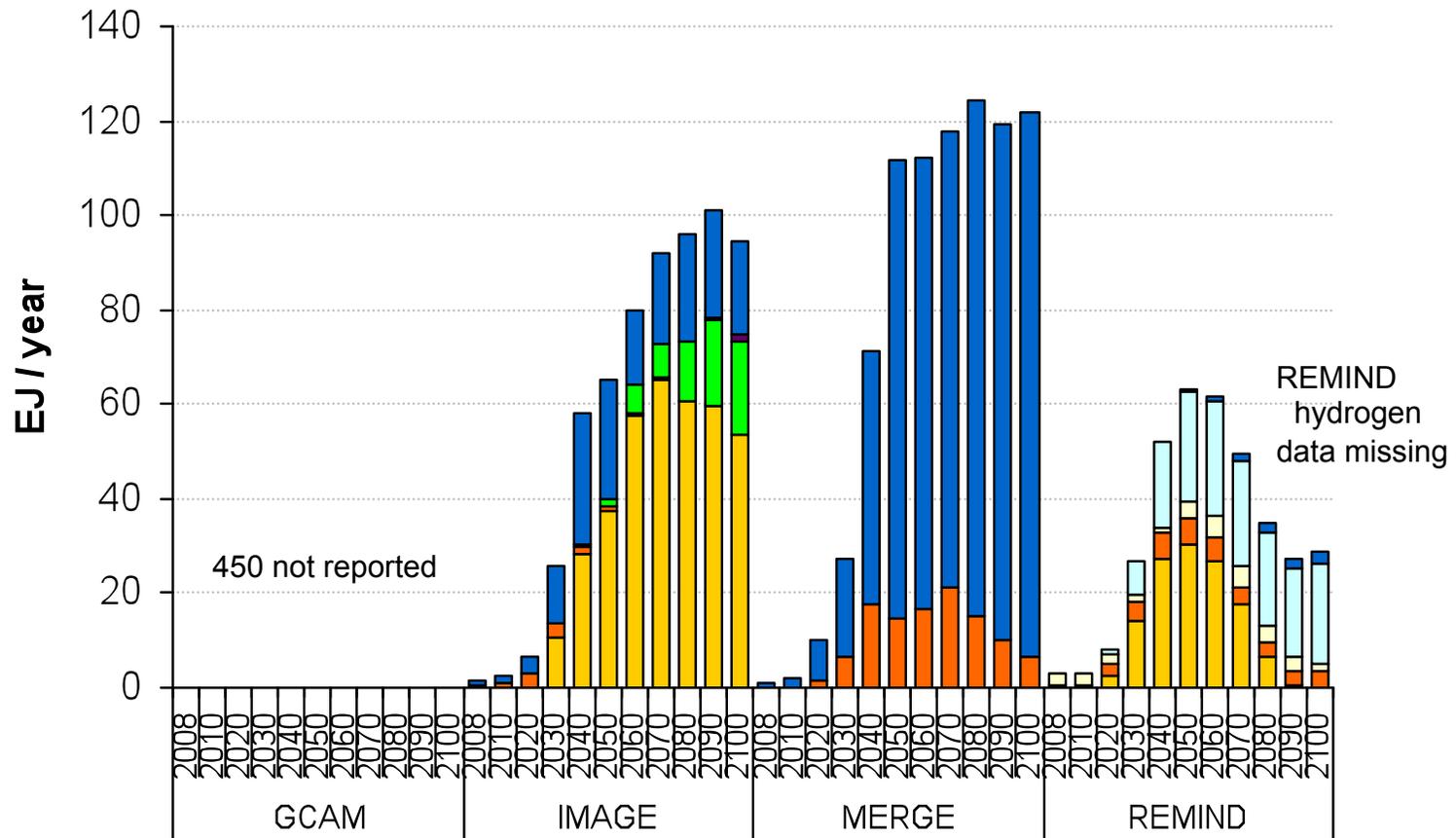
*Not for citation*

# Biomass secondary energy – 550 ppm policy



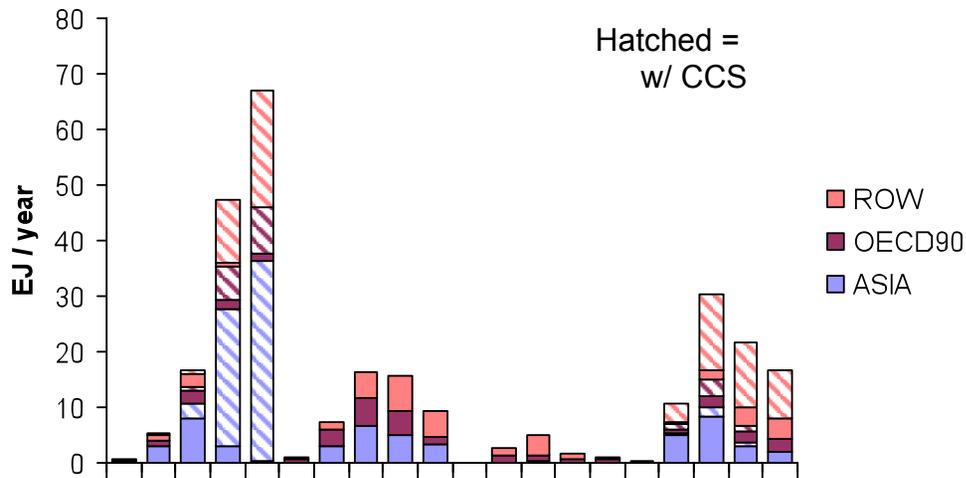
*Not for citation*

# Biomass secondary energy – 450 ppm policy



*Not for citation*

# Regional secondary bioenergy – 550 ppm policy



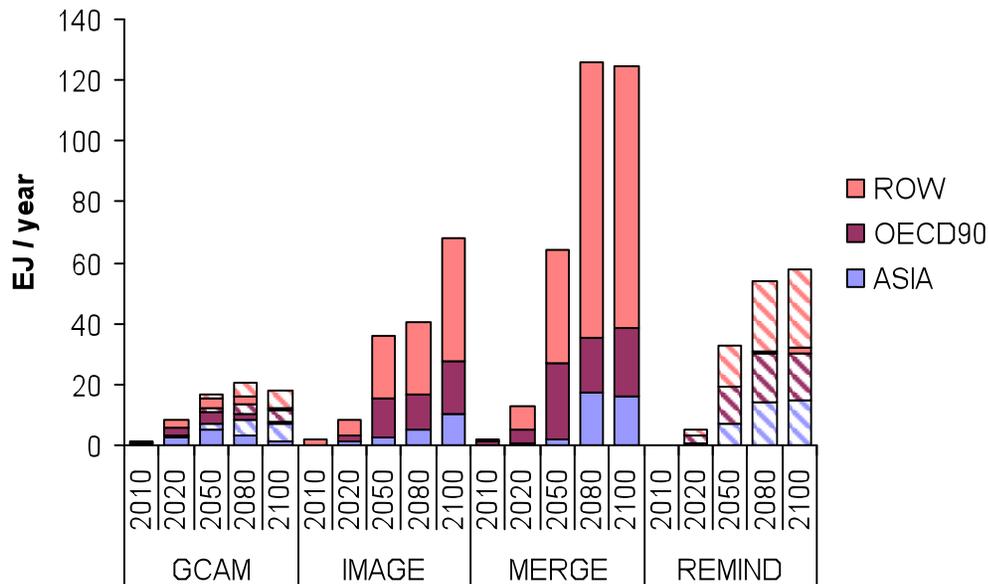
## Bioelectricity

Share of electricity in 2050:

ASIA: 3 – 14%

OECD: 2 – 10%

ROW: 4 – 30%



## Biofuels

Share of liquids in 2050:

ASIA: 7 – 27%

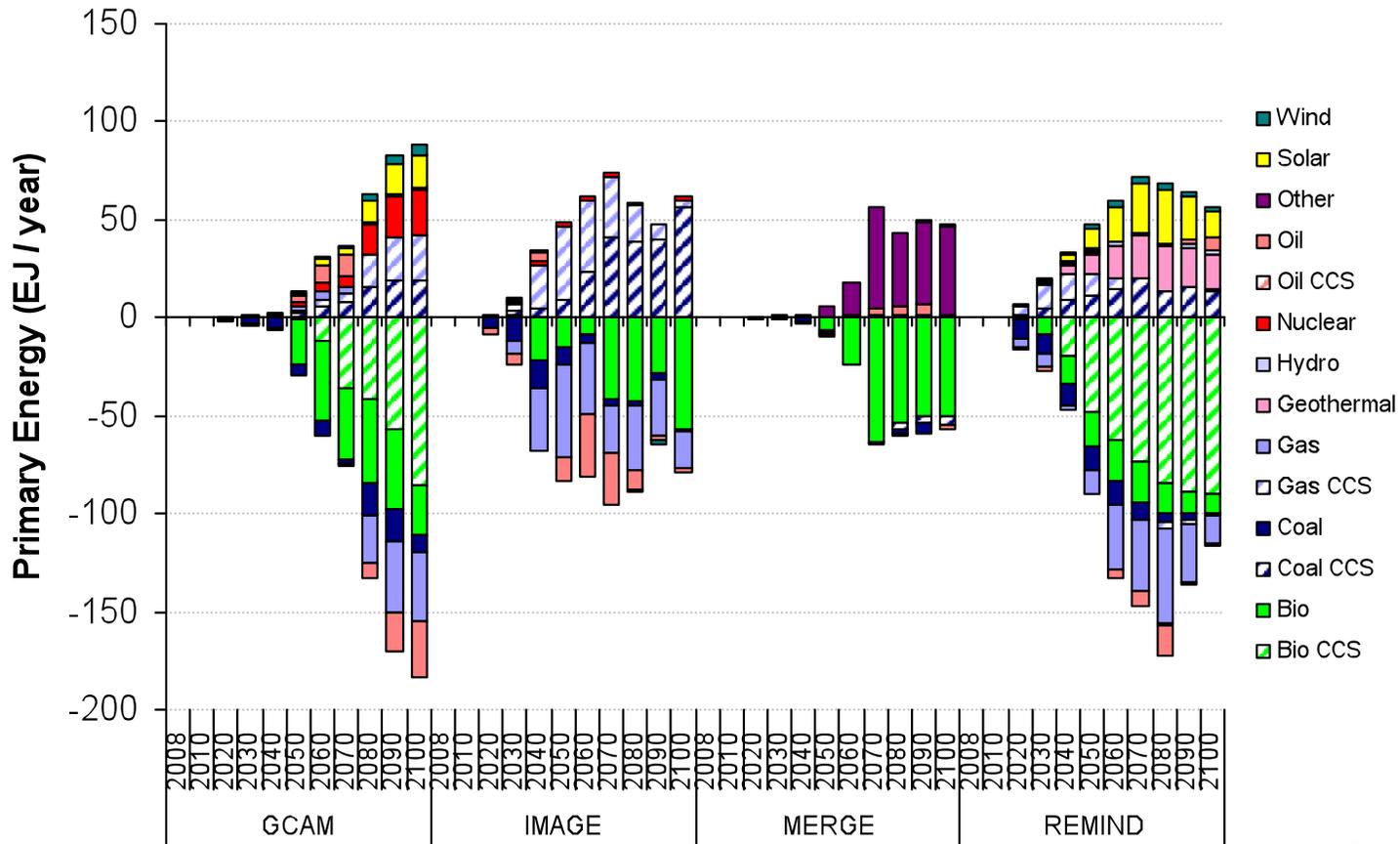
OECD: 7 – 99%

ROW: 7 – 69%

*Not for citation*

# What trades-off against bioenergy?

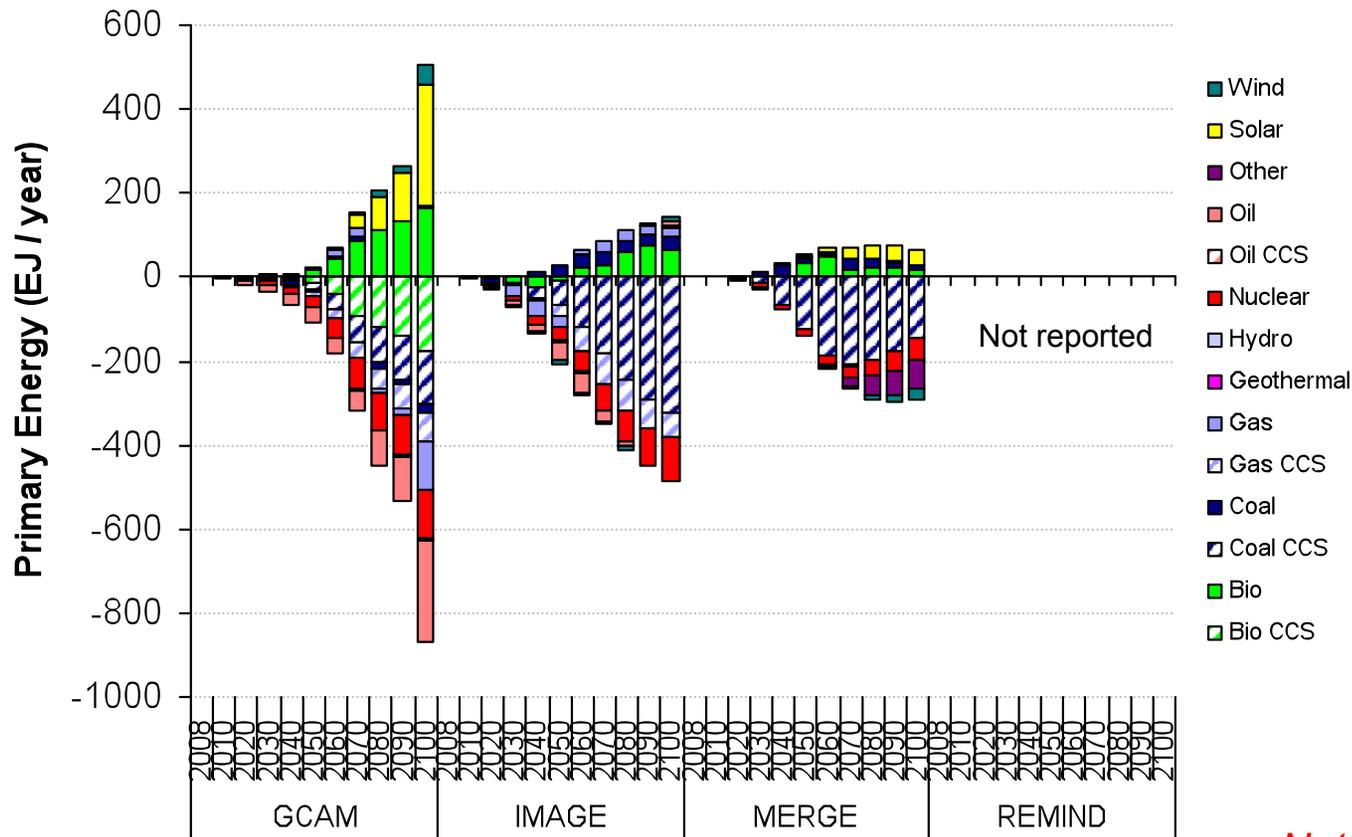
## 550 ppm w/ Constrained v Default Bioenergy



*Not for citation*

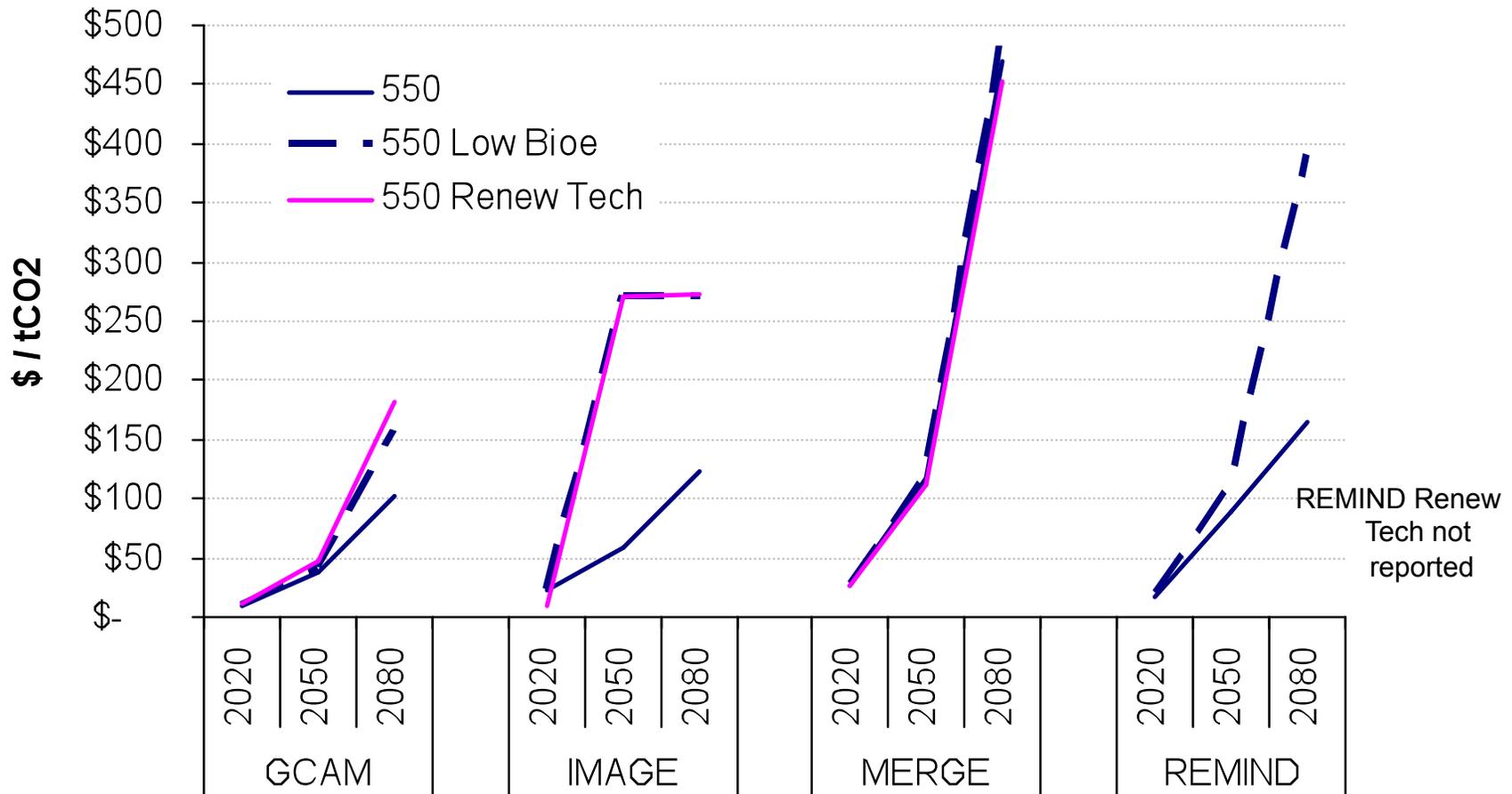
# How do renewables deploy with nuclear/CCS/ improved EI unavailable?

## 550 ppm w/ Renewable v Default Technologies



*Not for citation*

# Price responses to bioenergy availability?



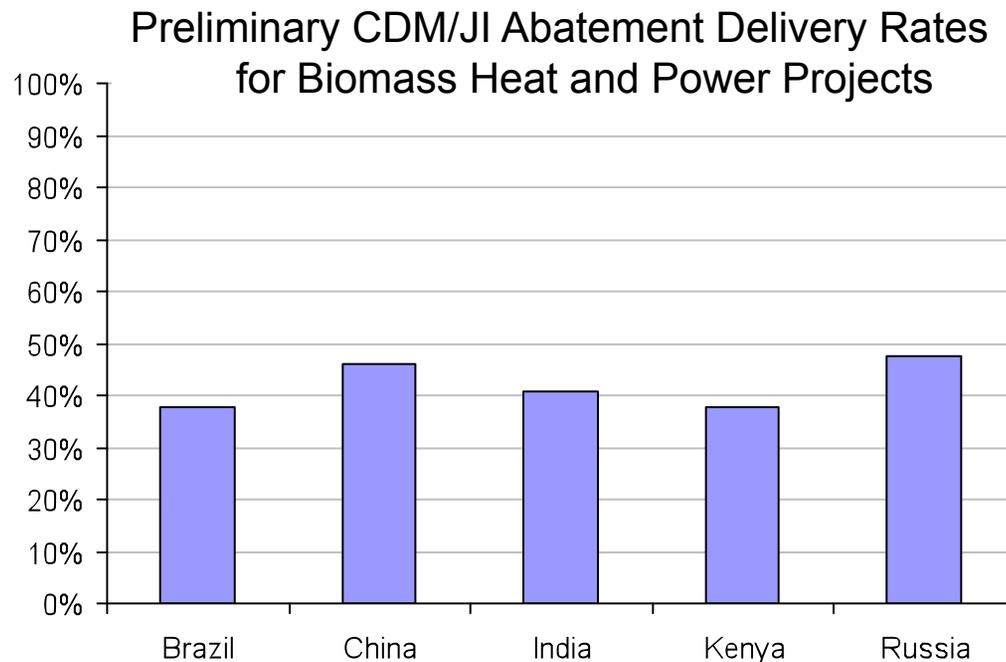
*Not for citation*

# Just the beginning of our exploration...

- Land-use change and management
- Emissions/sequestration
- Biomass feedstocks
- Conversion technologies
- Subgroup specific scenarios

# Another issue – Project investment risk

- Bioenergy projects
  - Key technology risks: ownership and monitoring complexity, feedstock supply
  - Country investment risks – general, carbon market



*EPRI (in progress)*

## Concluding thoughts

- IAMs would like bioenergy to be a significant part of energy transformation and climate management
- BioCCS essential for climate management?
  - Could be very helpful (and valuable) for getting to lower targets (especially in later half of century)
  - May be insufficient, *ceteris paribus*, if participation delayed
  - Could be a useful overshoot response technology
- No clear vision of the end-use disposition of bioenergy – but majority of use could be in non-OECD countries
- Bioenergy energy system trade-offs at the margin uncertain
- Much to assess to determine viability—social, environmental