Trading woody biomass and negative emissions under a climate mitigation scenario

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1. Introduction

- Bio-energy with CCS (BECCS) is a critical technology for low CO2 concentration targets

  Azar et al. 2006, 2010; Clarke et al. 2009; Edenhofer et al,. 2009, 2010; van Vuuren et al. 2011

- Uneven distribution of biomass endowment: Latin America and Sub-Saharan Africa have the largest potential

  Berndes et al., 2003; Rokityanskiy et al. 2007; Smeets et al. 2007; Heinimö et al., 2009; Chum et al., 2011

- Disparity between demand and supply

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2. Trading options

1. Physical trade of biomass

2. Trade of “carbon credits”

3. Long distance trade of bio-electricity

Ref. Schlamadinger et al., 2004; Hansson and Berndes, 2009; Laurijssen and Faaij, 2009

2. The WITCH model

- Scenarios developed using the WITCH integrated assessment model
- 13 world regions that interact in a strategic setting
- Economy: top-down intertemporal optimal growth model, dynamic, perfect foresight
- Mitigation options: power sector, land use, non-CO2 gases
- Endogenous technical change in energy sector
- Endogenous price of fuels and of renewables
- Biomass supply curves from GLOBIOM model (Havlík et al. 2011)

3. Biomass trade in WITCH: Equations

$$WBIOd_{n,t} = WBIOigcc_{n,t} + WBIOpc_{n,t} \quad (1)$$

Without trade:

$$WBIOd_{n,t} = WBIOs_{n,t} \quad WBIOs_{n,t} \leq E^{*}_{n,t} \quad (2)$$

With trade:

$$WBIOd_{n,t} = WBIOs_{n,t} + NIPwbio_{n,t} \quad (3)$$

$$\sum_n \mathrm{NIPwbio}_n = 0 \;\; \forall t \quad (4)$$

$$\begin{aligned} Ynet(n,t) = & \frac{GY_{n,t}}{\Omega_{n,t}} \\ & - \sum_q Pq_{n,t} \, Vq_{n,t} \\ & - cwbio_{n,t} WBIOs_{n,t} \\ & - pwbio_t NIPwbio_{n,t} \end{aligned} \quad (5)$$

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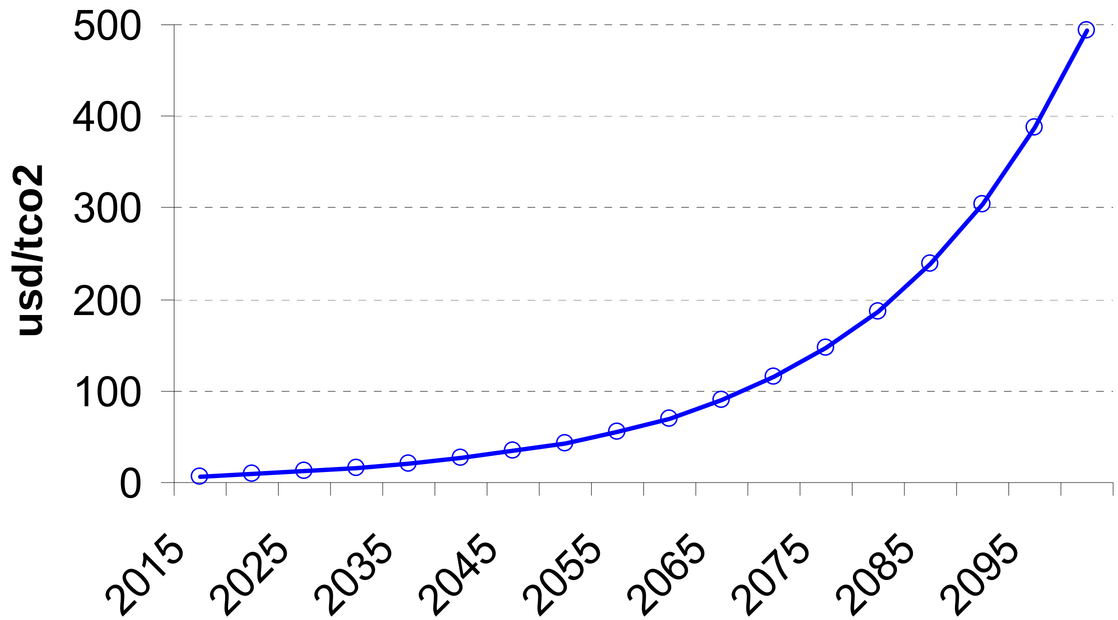
4. Scenarios



- Mitigation scenario: carbon tax on all GHG emissions **with and without woody biomass trade**
- Recyclied lump-sum in the economy
- BECCS power plants receive a subsidy equals to the CT
- Increase in temperature of 2.5C

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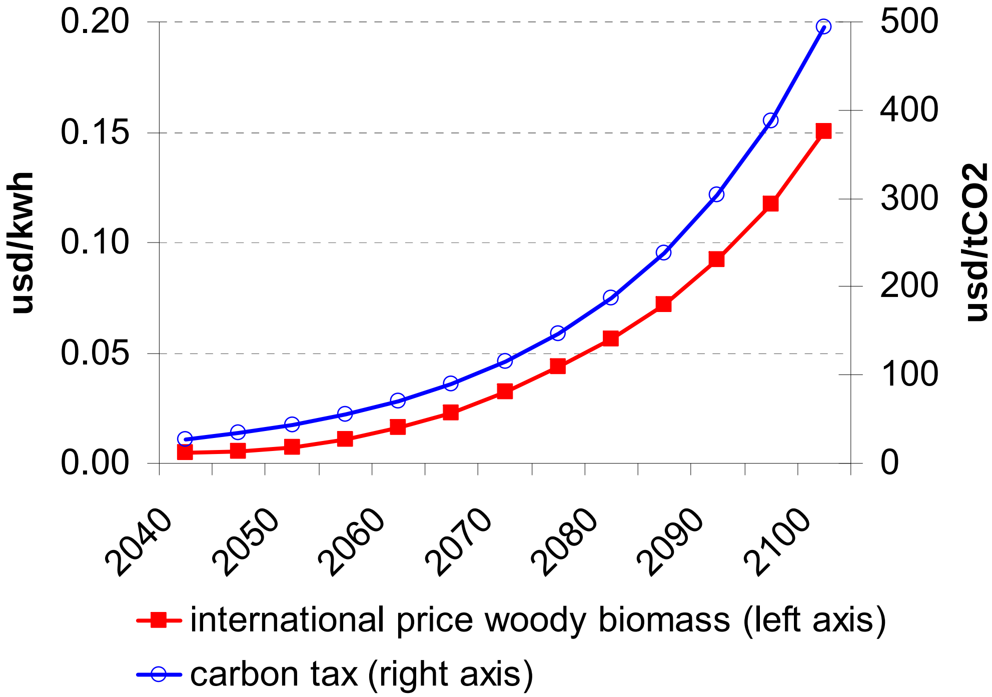
5. International price of woody biomass



- It emerges endogenously as an outcome of a non-competitive Nash game among all regions
- It follows the carbon tax path

1 m^3 of biomass produces 7.5GJ

2040: 10usd/m^3; 2100: 313 usd/m^3

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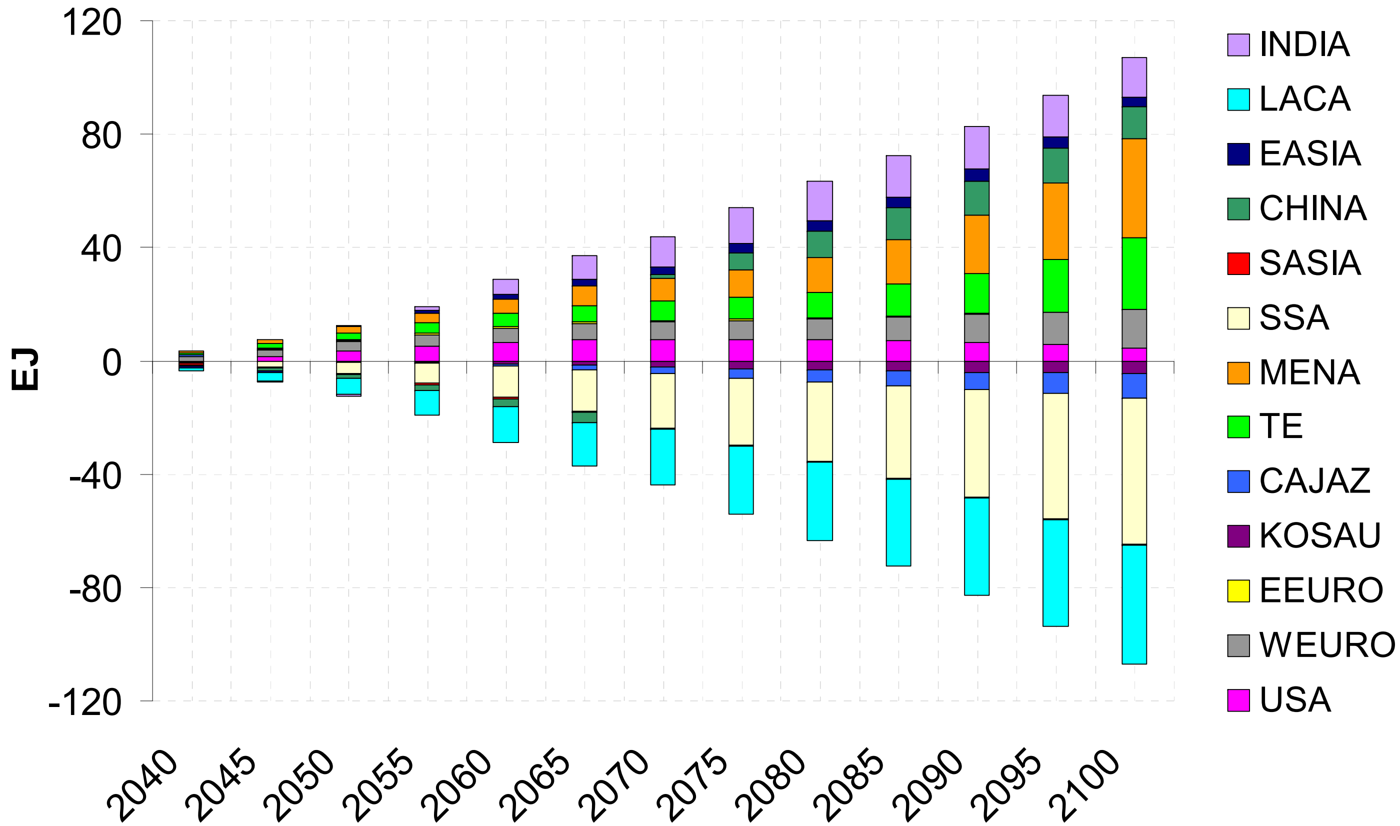
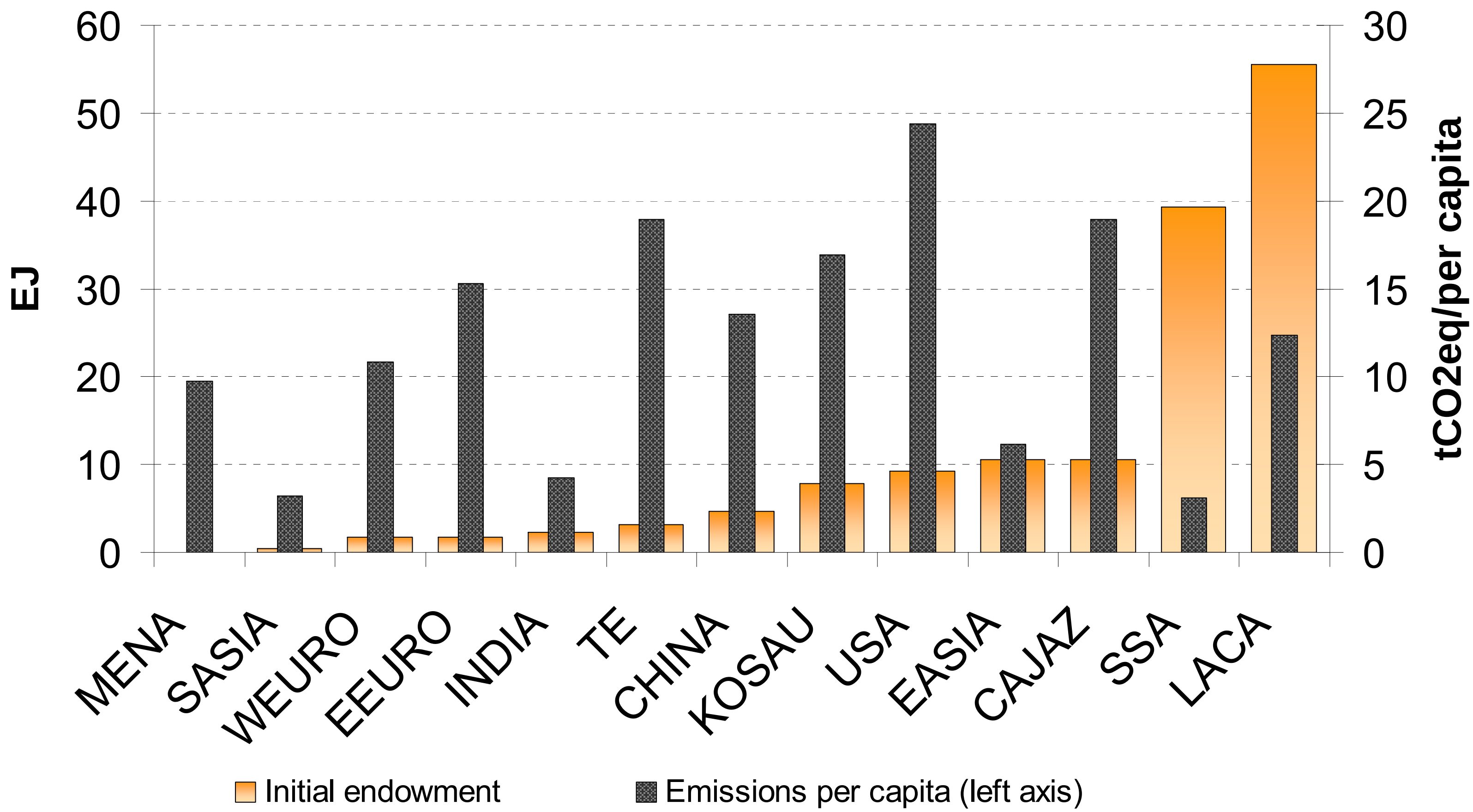
6. International mkt



- Market volume: 107 EJ/yr (more than 50% of the biomass consumed globally)
- Market value: 4,468 USD Billions in 2100 (1.3% GWP)

Biomass potential - 2050



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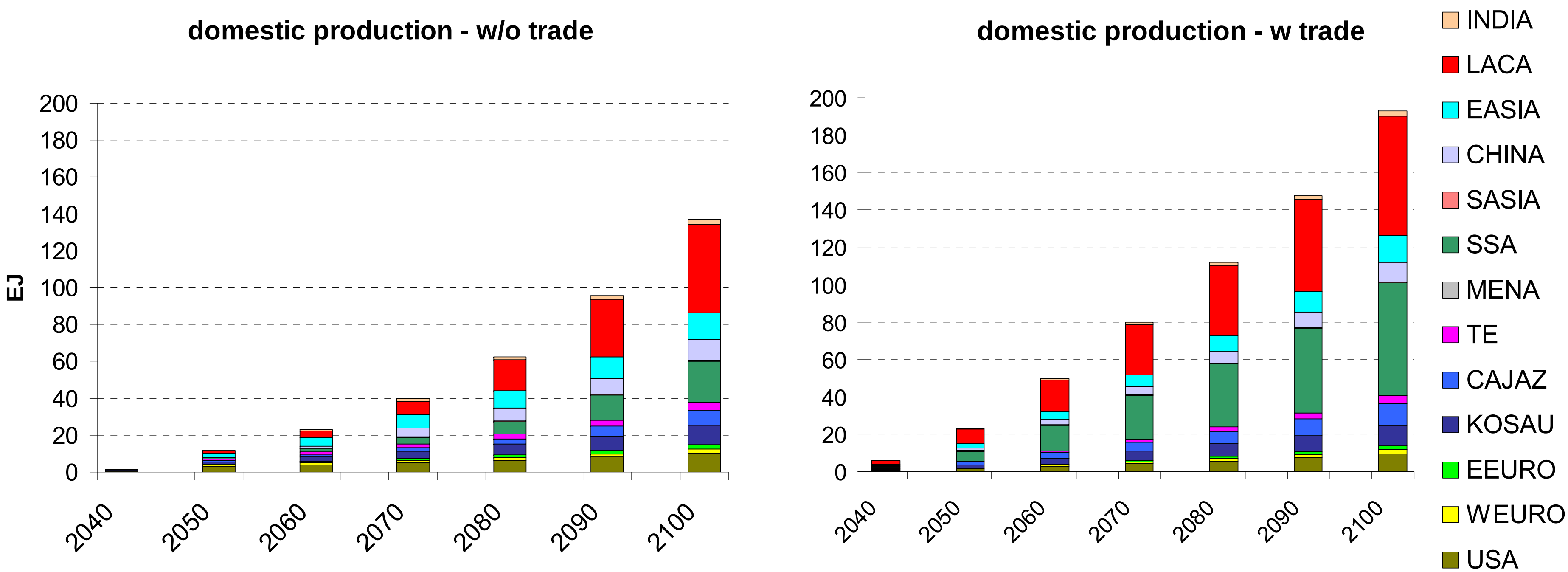
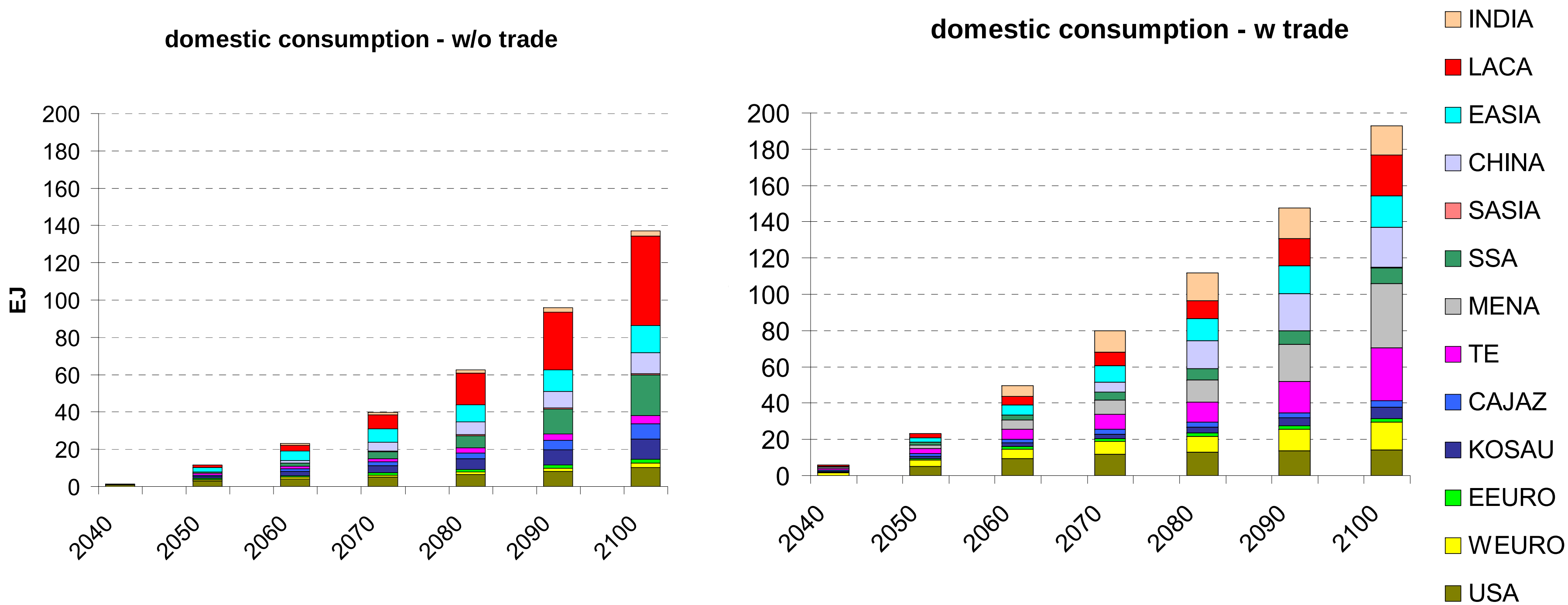
7. Biomass production



- With trade it increases by 40%
- All biomass potential is used by 2100

8. Biomass consumption



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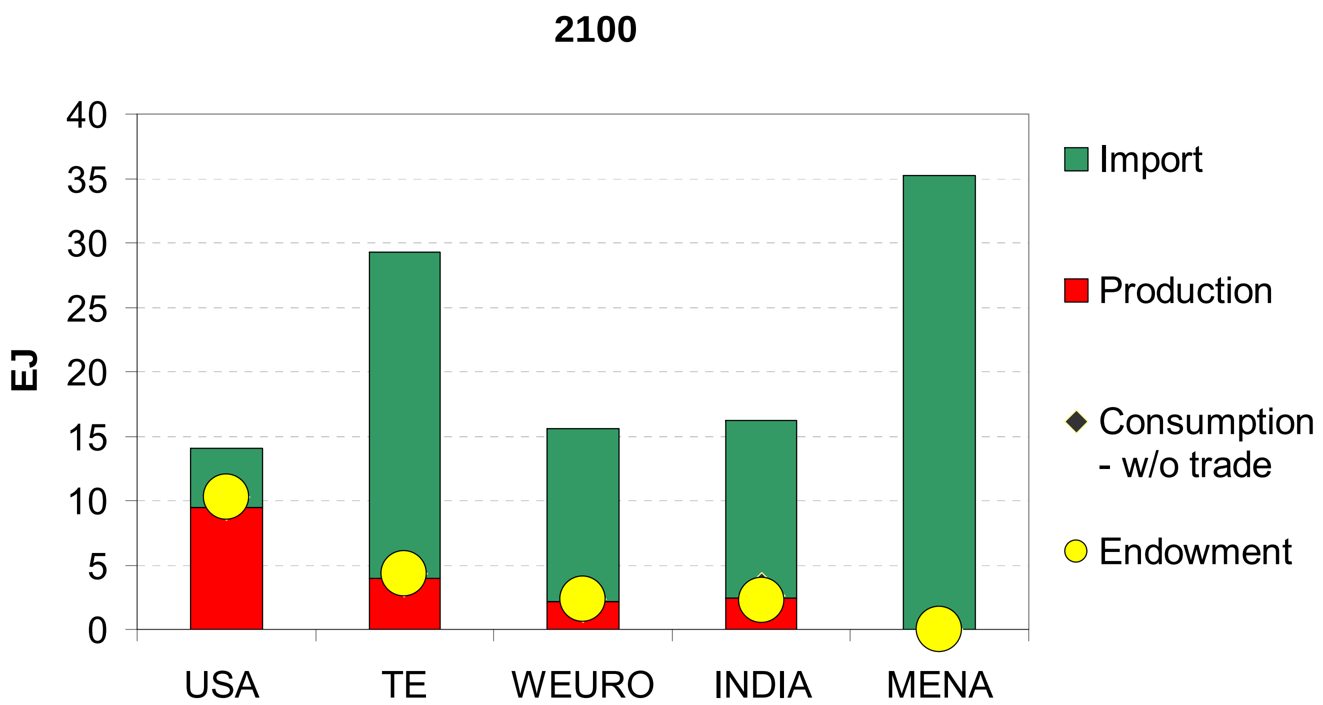
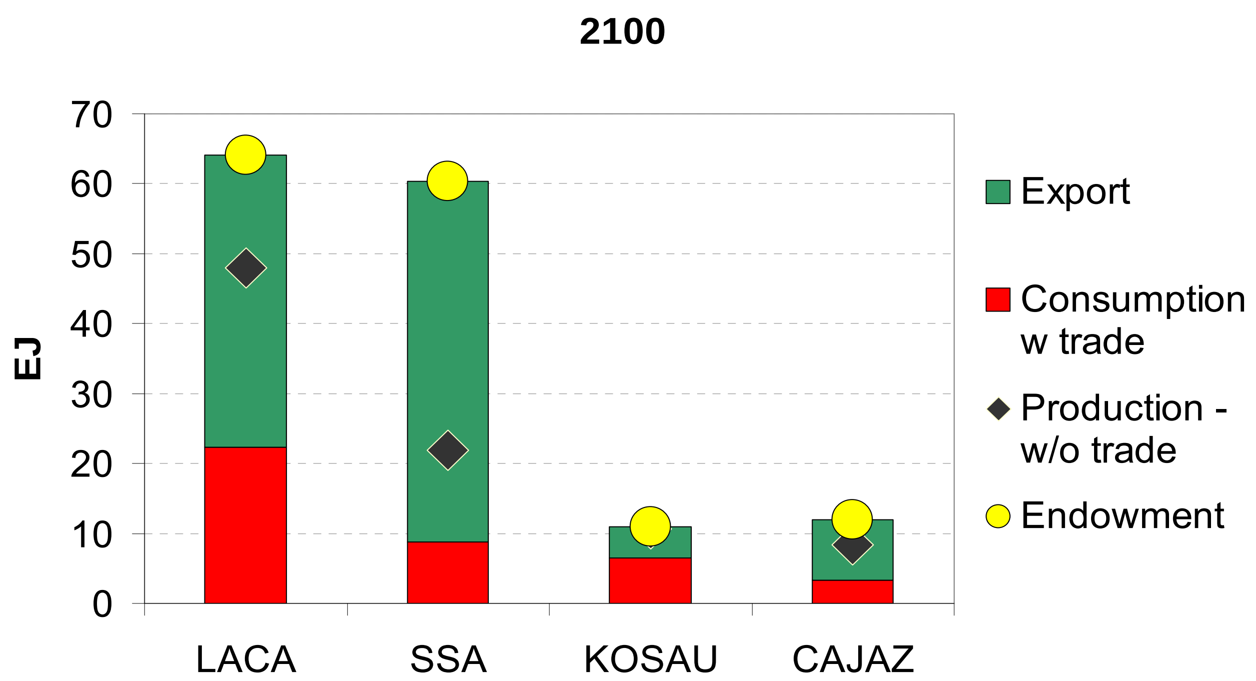
9. Biomass consumption - importing regions



Domestic consumption = max potential

High share of import on the total biomass consumption

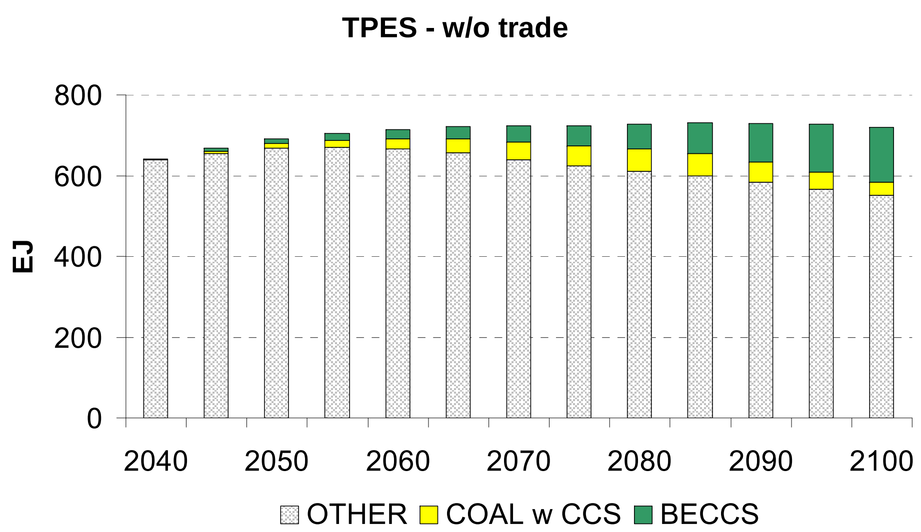
10. Total production - Exporting regions

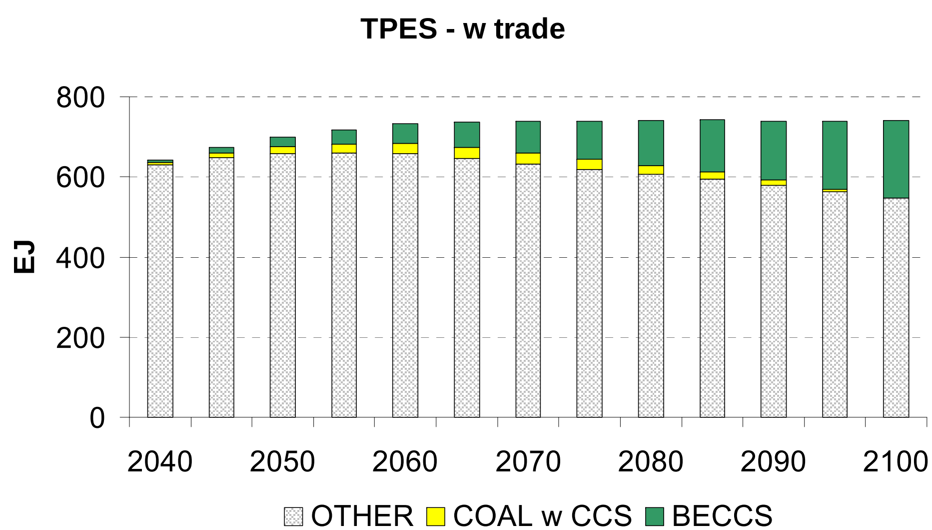


Production = total endowment

Share of exports: 65% LACA (↓); 85% SSA (↑); 40% KOSAU (↓); 70% CAJAZ (↑)

11. A new energy mix - World





- BECCS increases from 19% to 26%
- Coal+CCS decreases from 4% to 0%
  - Competition for the same CCS site
  - Substitute
- Nuclear decreases in importing countries and grows in exporting countries
  - large scale, virtually carbon free technology

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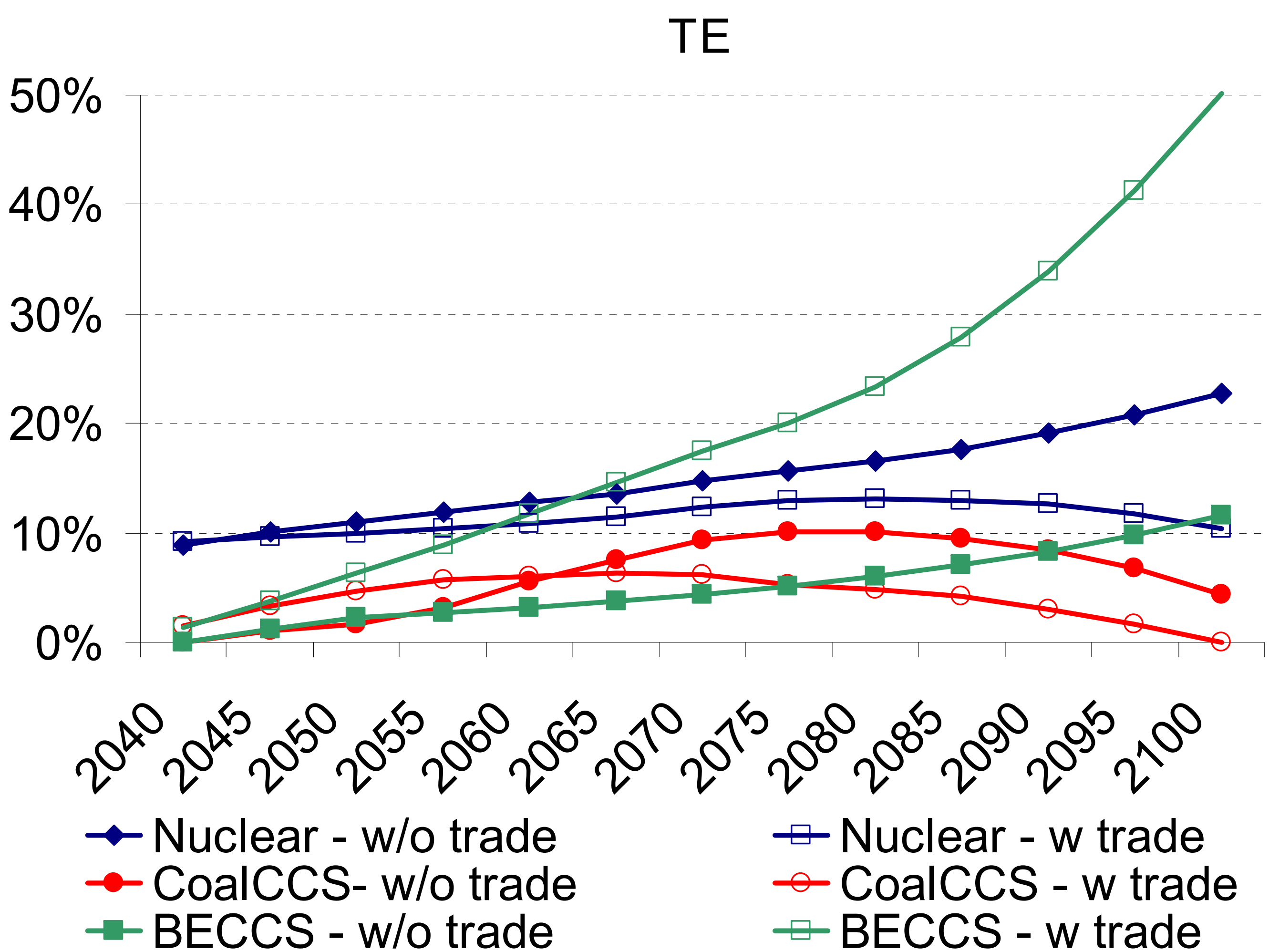
TPES - Transition Economies



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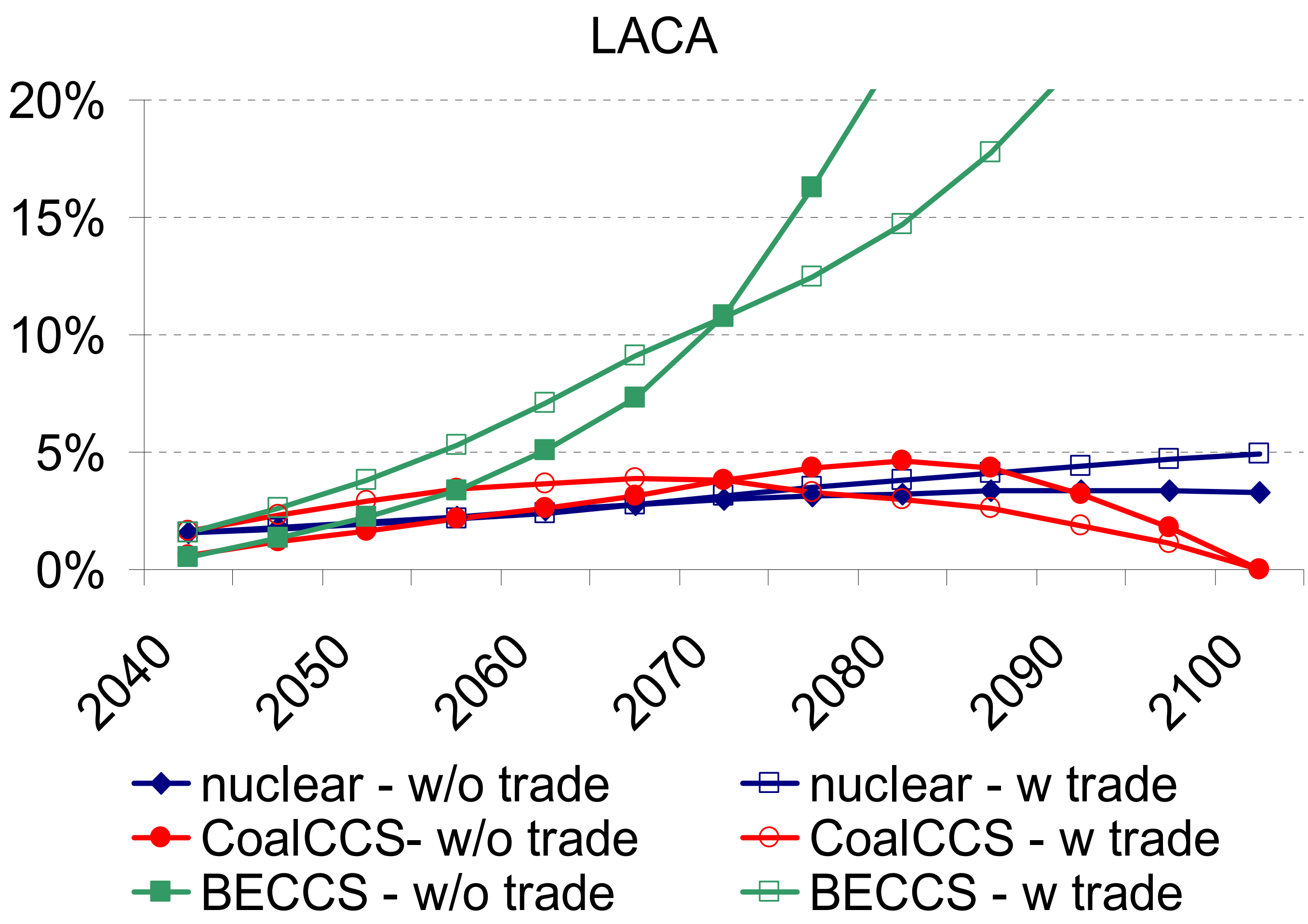
TPES – Latin America



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12. Trade effects on the optimal abatement level

- Trade of biomass, new abatement opportunities: more clean energy and CO2 sequestration
- With trade the MC curve shifts to the right
  - for the same carbon tax there is more abatement
- Comparing the same scenario with and w/o trade:
  - Trade offers a 20% GHGs reduction by 2100
  - Negative emissions increase by 22%
  - 6% reduction in the energy intensity and 17% in the carbon intensity

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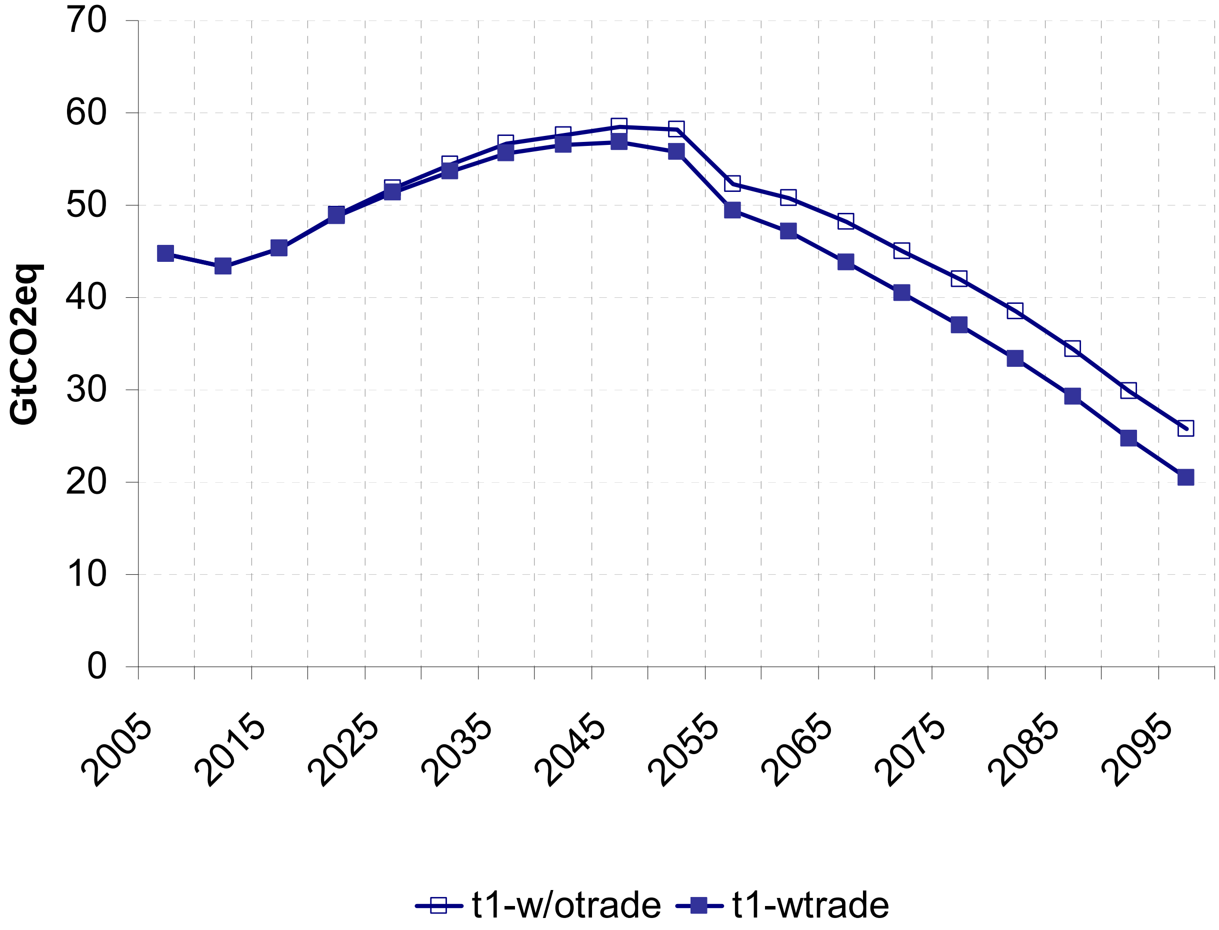
GHGs emissions w/o and w trade



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14. Future developments

- **Transportation costs**
- **Sensitivity analysis**
- Inclusion of the **carbon market** (cap-and-trade)
  - Focus on interactions between the two markets
- **Trade of bio-electricity**
- **Soft link** with a forest model
  - Competition with other forestland use

Thanks

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