Efficient co-generation of energy products in pulp industry

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Aim

To compare **potential** production of electricity and motor fuels in pulp mills using

- Conventional recovery boiler (RB) - reference
- Black liquor gasification combined cycle (BLGCC)
- Black liquor gasification for motor fuels (BLGMF)

The presentation is mainly based on: Holmberg, J.M. and Gustavsson, L., *CO_2 and oil use reduction by implementation of black liquor gasification and energy efficiency in pulp and paper industry* (journal article manuscript).

Background, drivers

- Climate change
  - Use of biomass-based energy to replace fossil-based energy
  - Better effect when carbon intensive energy is replaced, e.g. coal-based electricity
- Oil dependency
  - Specific policy targets for reduced use of oil
  - Biomass-based fuels to replace petroleum products in transportation sector
- ➢ The objective is (at least) dual
  - Not optimize for one or the other objective

Pulp and paper mills

- Accounts for about one third of the roundwood use in Europe, in Sweden about 50%.
- Already co-produce fibre products, steam and electricity from biomass
- Have infrastructure and competence for handling large amounts of biomass
- Use large transportation fleets – potential for introduction of new transportation fuels with centralized refuelling

Studied alternatives

Bleached softwood kraft pulp

RB	BLGCC	BLGMF
Conventional recovery boiler	Black liquor gasification	Black liquor gasification
• Back pressure and condensing steam turbines	• Combined Cycle gas and steam turbines	• Back pressure steam turbine • DME synthesis
Electricity Surplus	**Electricity** surplus	**Motor Fuel** surplus

Data based on Berglin et al., 2003, *Preliminary economics of black liquor gasification with motor fuels production,* Colloquium on Black liquor Combustion and gasification, Park City, Utah, May 13-16 2003.

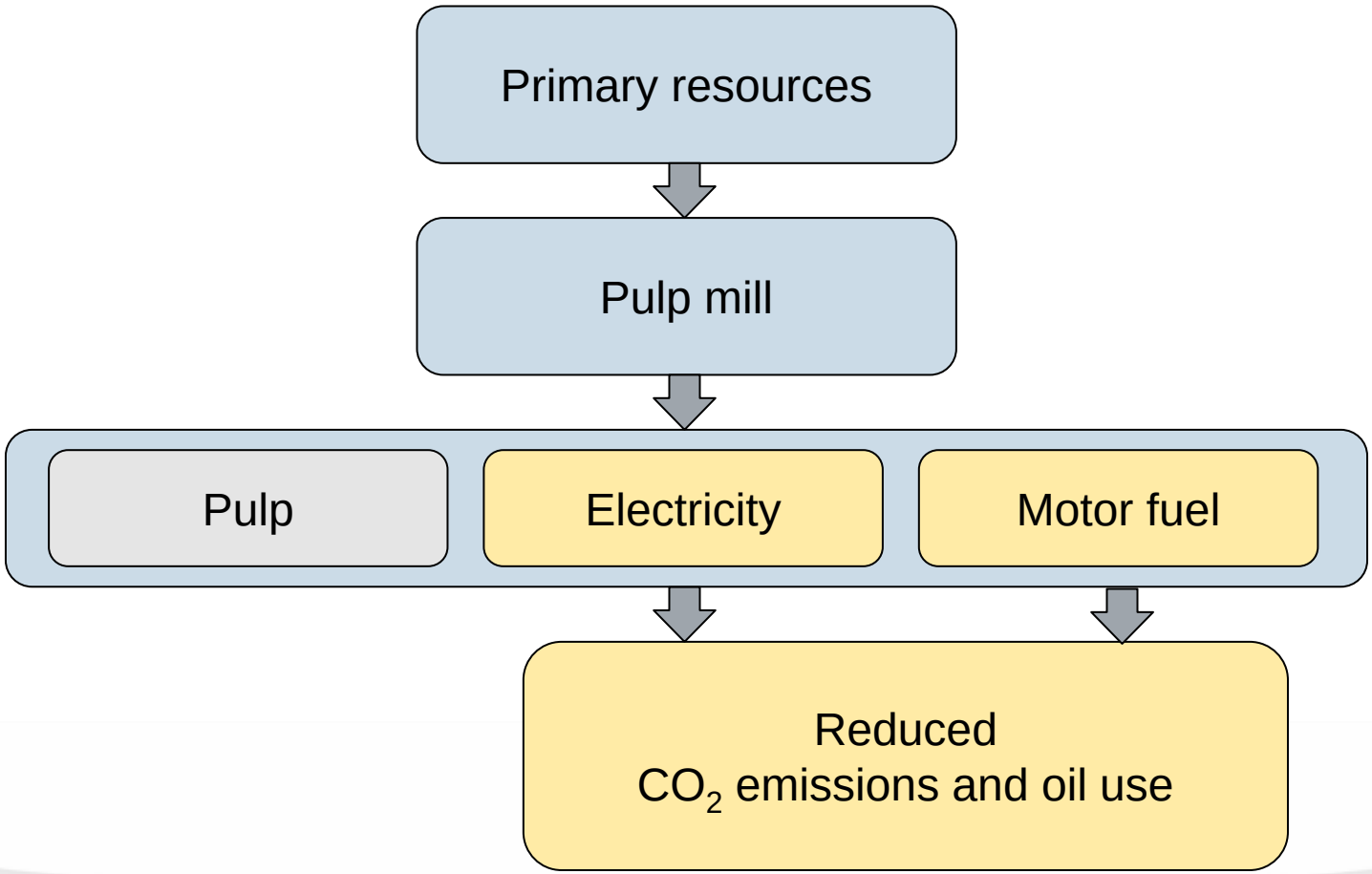
Parameters studied

- CO_2 emission
- Oil use
- Biomass use
- Total primary energy use
- Monetary costs
  - Lifetime of 25 years for energy plant and pulp mill investments
  - Discount rate of 6%

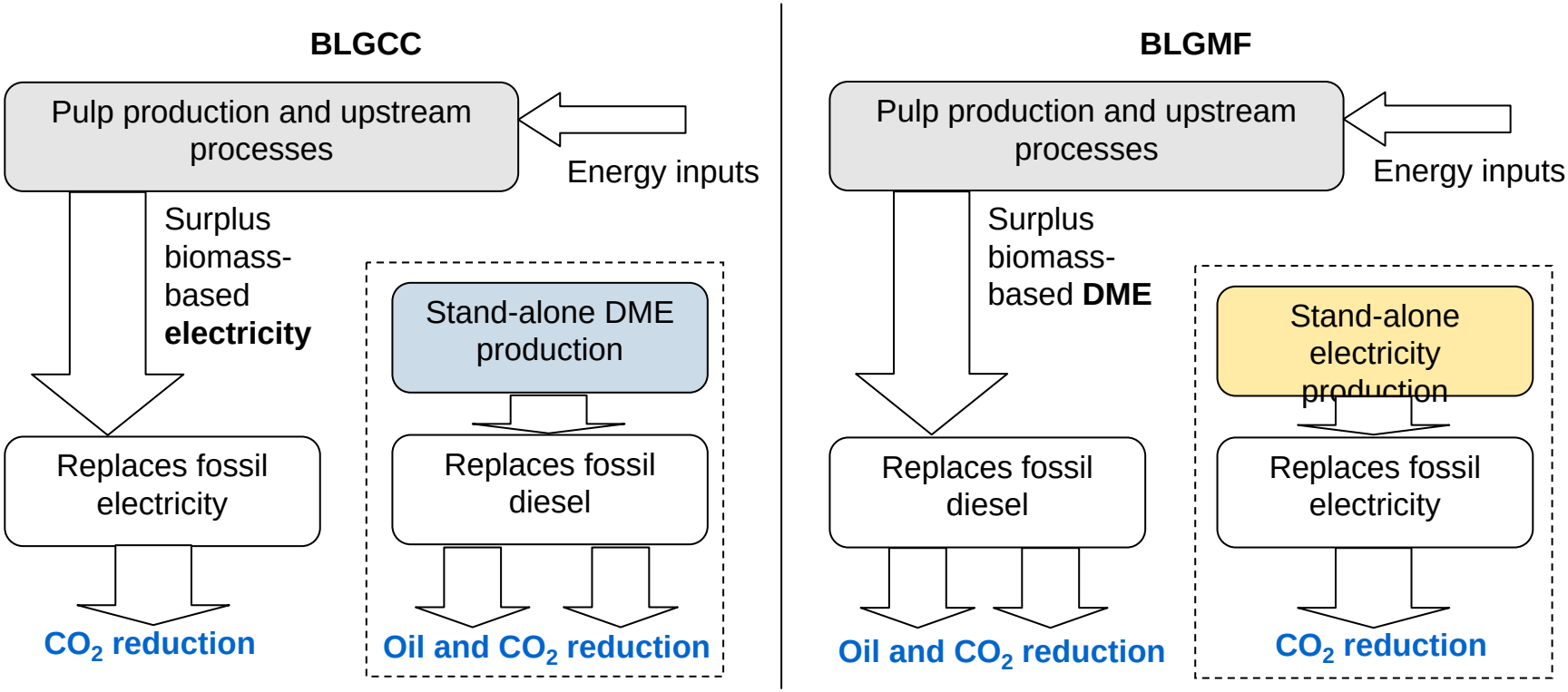
Assumptions

- Chemical pulp mills
- Bleached softwood kraft
- Based on Swedish conditions
- Data from model mills (based on KAM project)
- Energy demand in the mill is met with forest biomass

From primary resources to final products



Same CO_2 emission and oil use reduction



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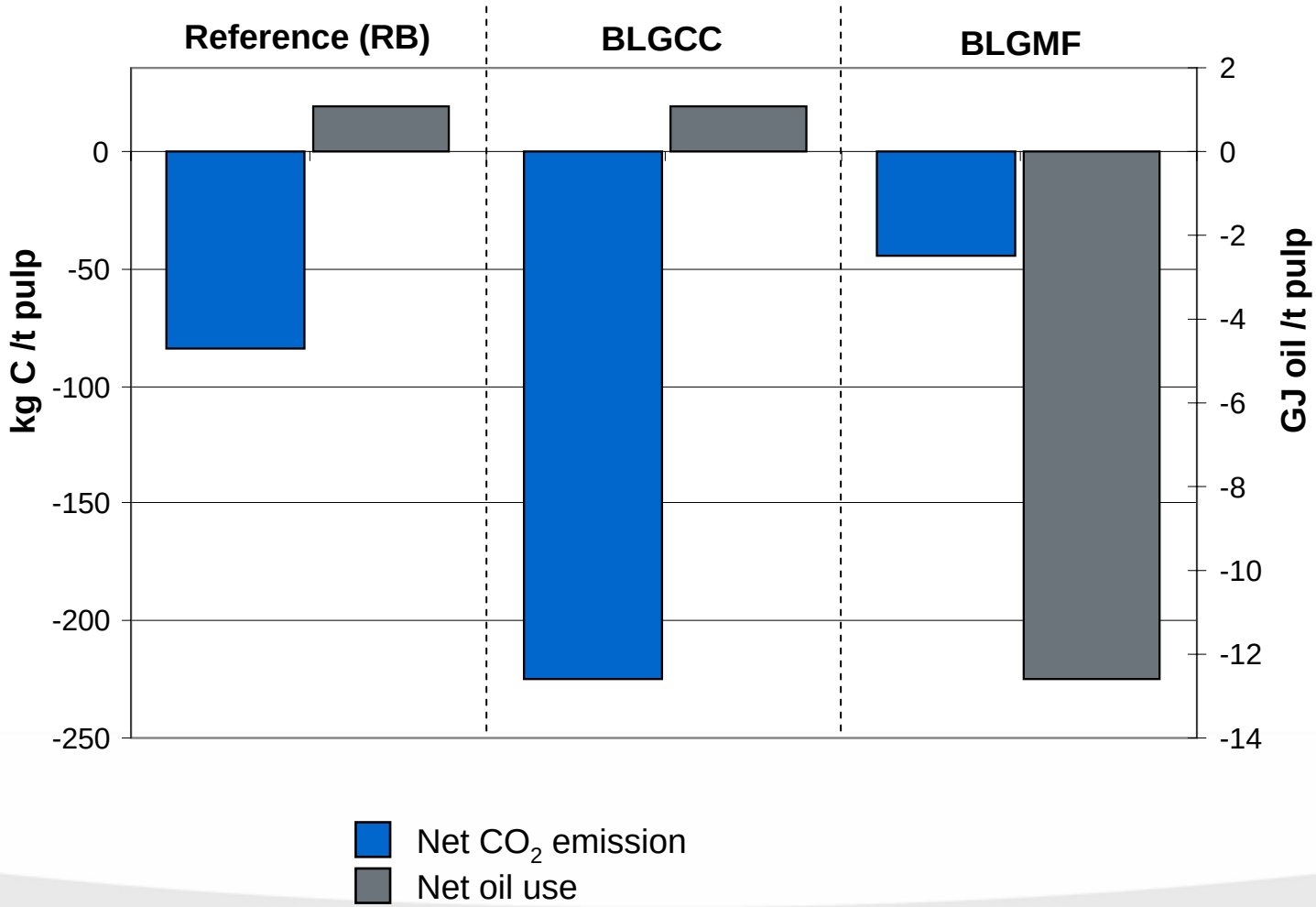
Assumptions energy supply

- Stand-alone biomass-based electricity
  - Integrated gasification with combined cycle (BIG/CC)
  - 47% conversion efficiency
- Stand-alone biomass-based DME
  - Gasification and fuel synthesis
  - 63% conversion efficiency
  - 0.11 GJ auxiliary electricity use / GJ DME
- Fossil energy replaced
  - Coal-based electricity (47% conversion efficiency)
  - Diesel as transportation fuel

Co-generation in pulp mill and stand-alone production
GJ per ton pulp

	RB		BLGCC		BLGMF	
	Electricity	**Fuels**	**Electricity**	**Fuels**	**Electricity**	**Fuels**
Co-generation, gross	5.4	0	8.9	0	1.4	13.5
Stand-alone generation	2,3	13.9	**0**	13.7	6.0	**0**
Process use and energy system own use	-5.2	-2.3	-6.4	-2.1	-4.9	-1.9
Net export	**2.4**	**11.6**	**2.4**	**11.6**	**2.4**	**11.6**

CO_2 emission and oil use balance *without* stand-alone production



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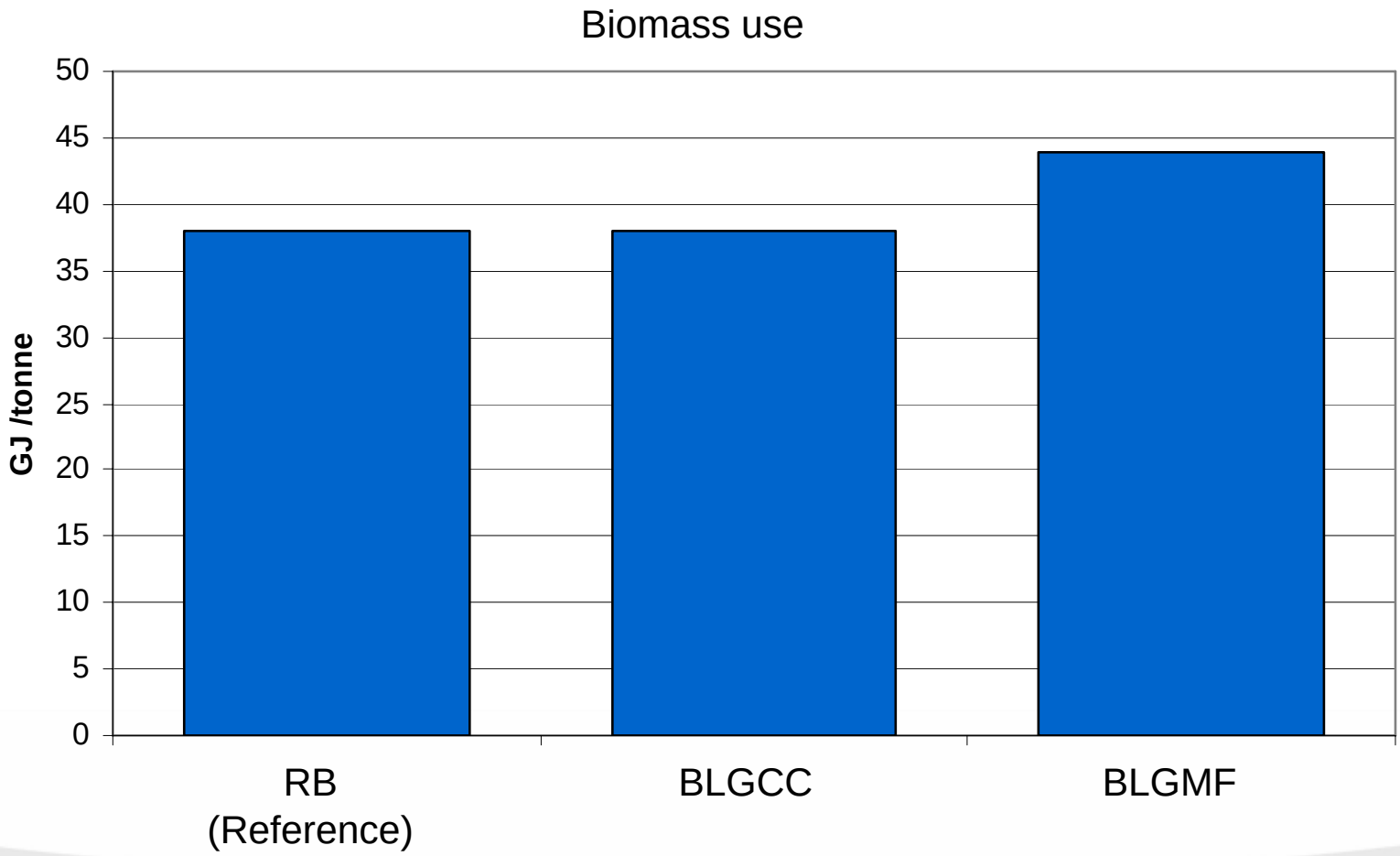
Biomass use without stand-alone production



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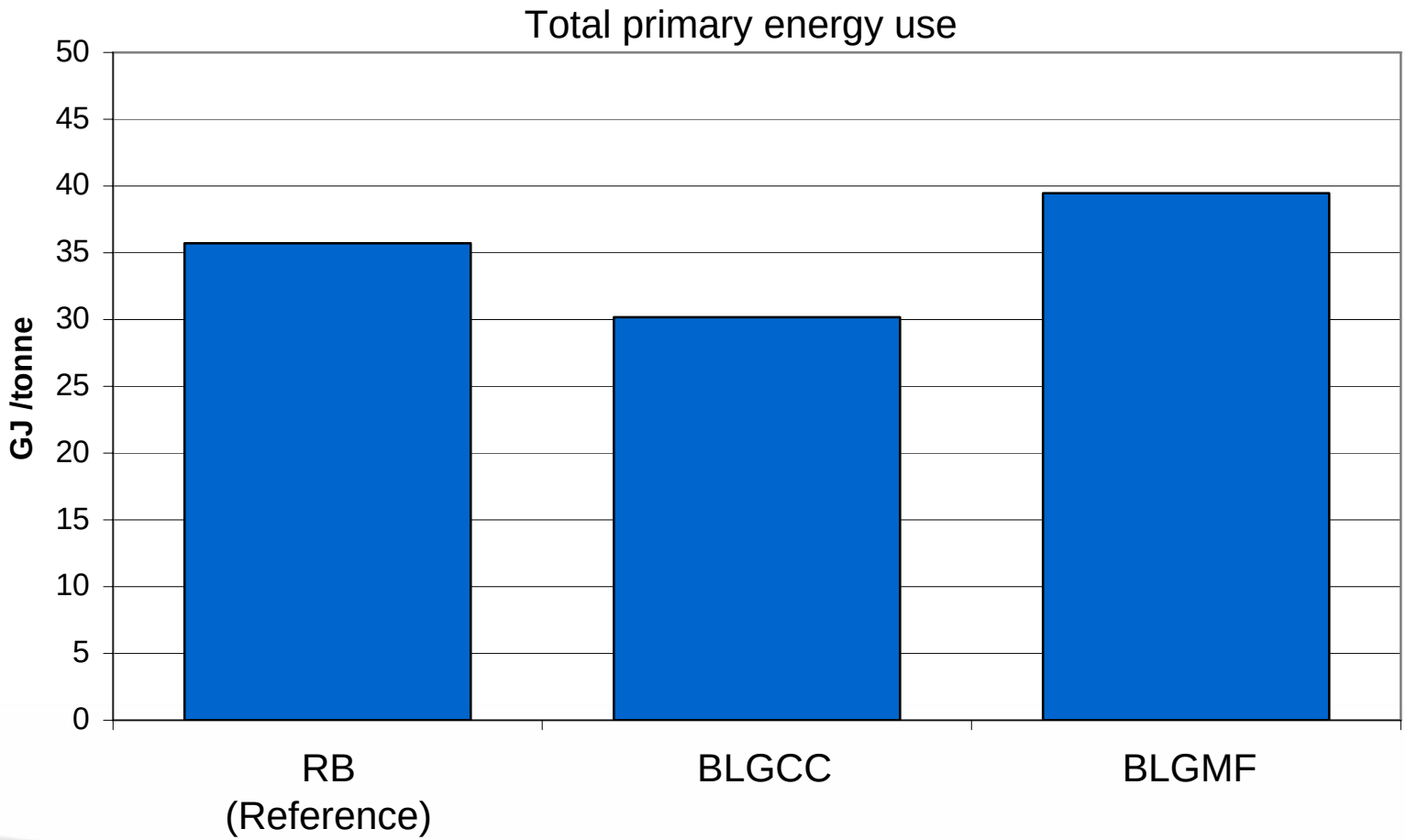
Primary energy use without stand-alone production



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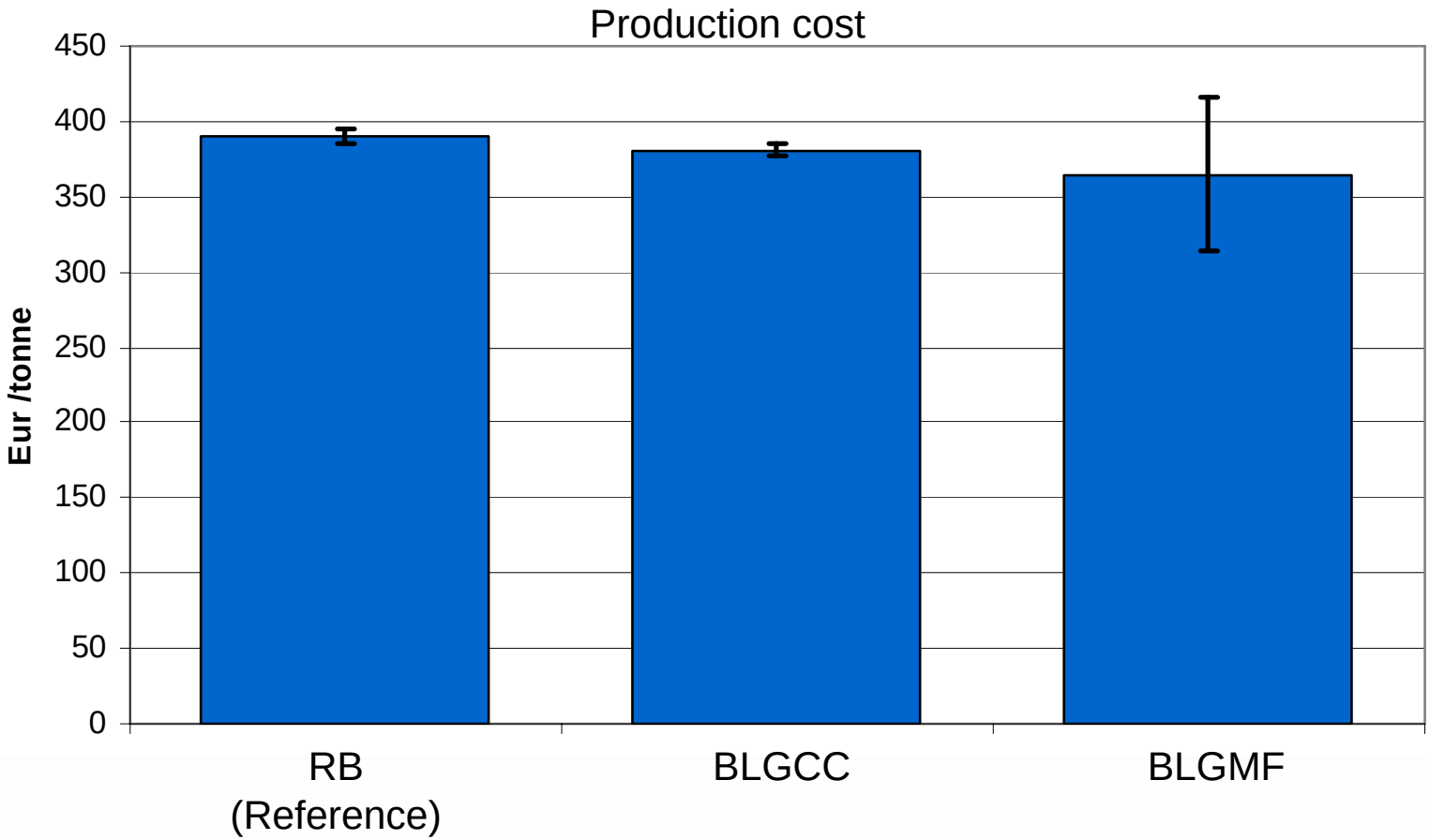
Production cost without stand-alone production



Oil price variation 20-60 US$/barrel, default 40 US$/barrel

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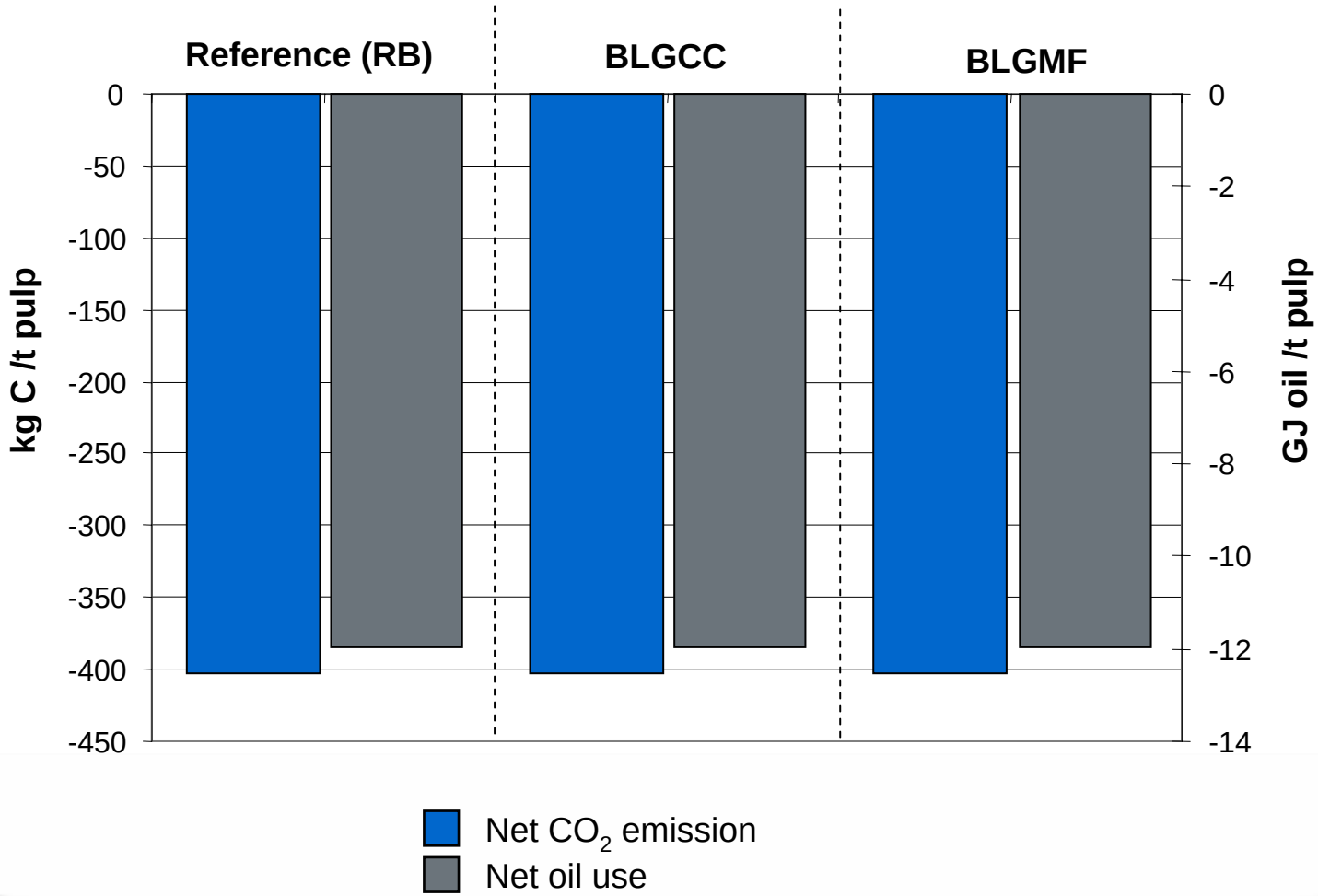
CO_2 emission and oil use balance with stand-alone production



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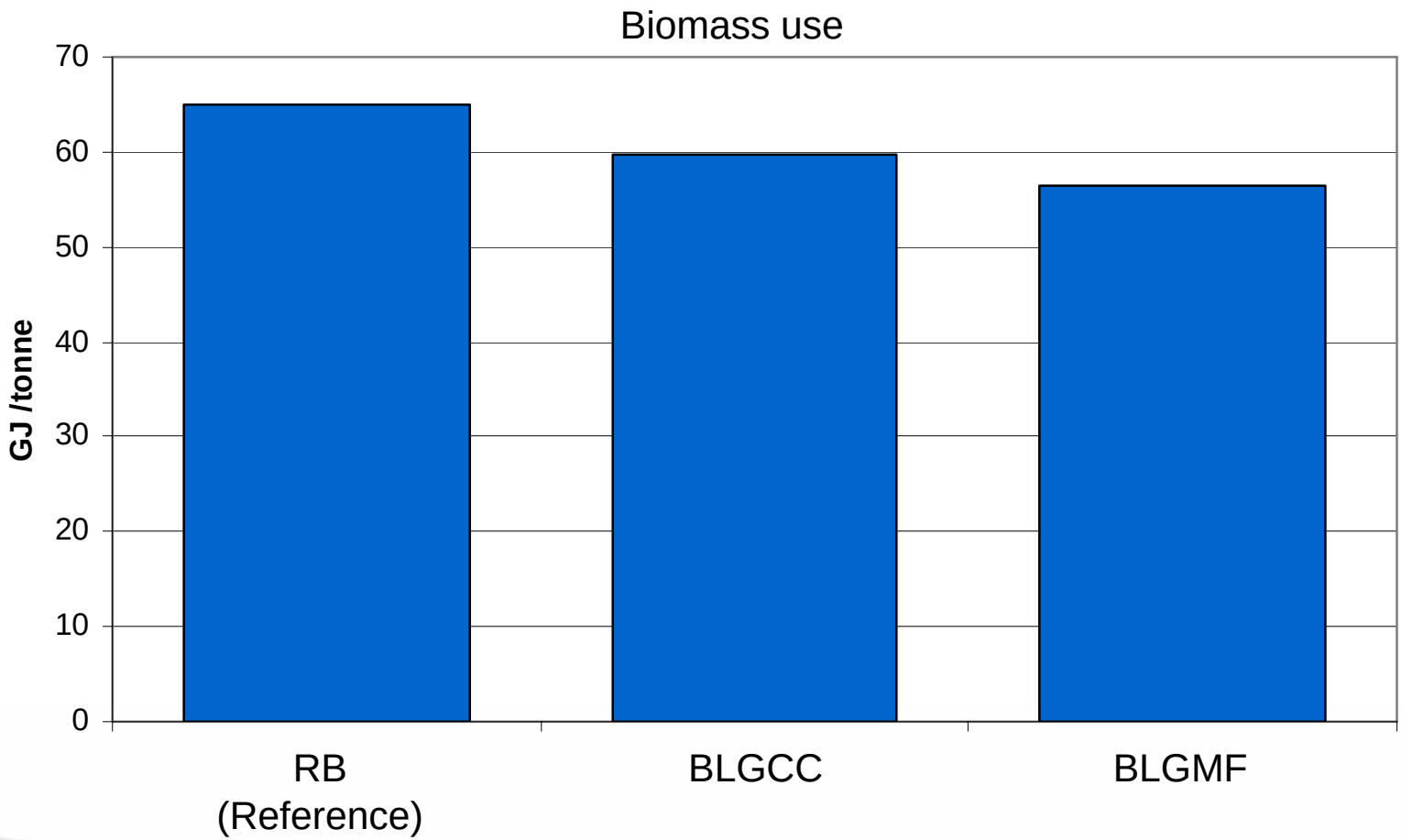
Biomass use with stand-alone production



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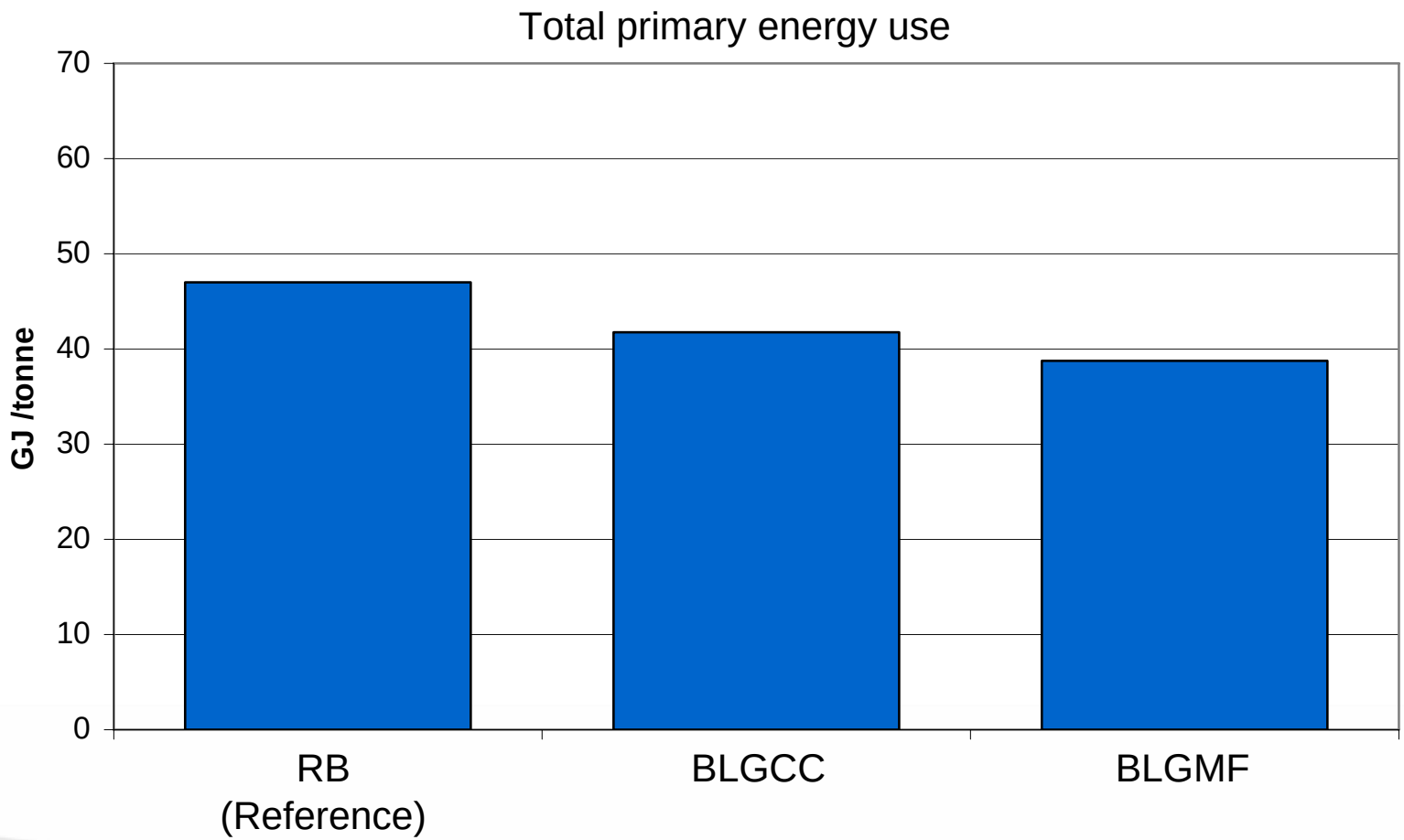
Primary energy use with stand-alone production



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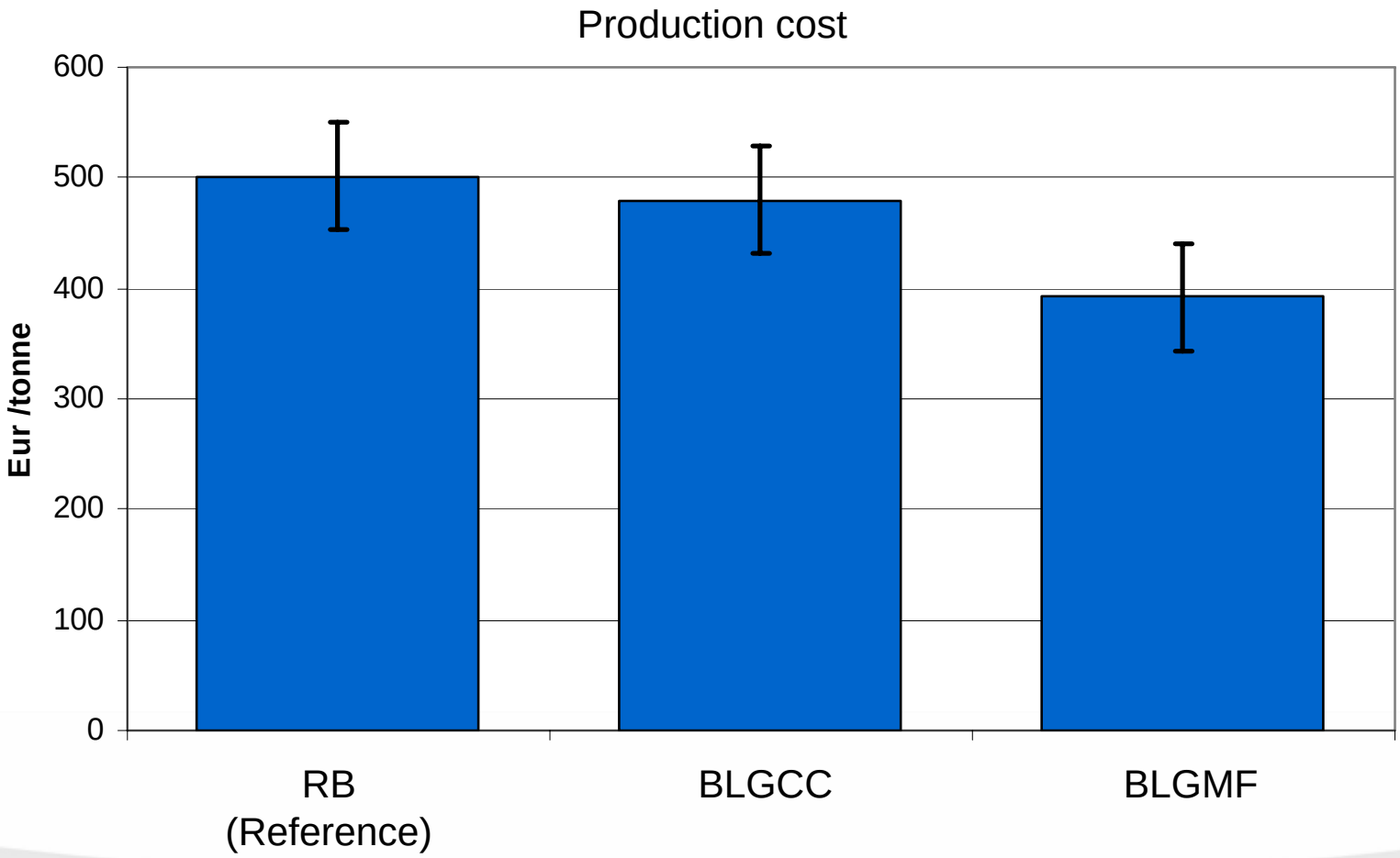
Production cost with stand-alone production



Oil price variation 20-60 US$/barrel, default 40 US$/barrel

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Production of sulphate pulp

M tonne	Bleached	Unbleached	Total
Sweden	4.9	2.1	7.0
Europe	19	6.5	26
Global	79	30	109

BLGMF implementation for all *bleached sulphate pulp* in Sweden could replace ~65 PJ of diesel annually, or about 47% current Swedish use of diesel.

Pulp data for 2005 from FAOSTAT. Diesel use 2003 according to statistics Sweden.

Conclusions

- BLG in chemical pulp mills gives lower biomass use, primary energy use and monetary costs than stand-alone production of fuels and electricity from biomass.
- BLGMF is to prefer if we want both CO_2 emission and oil use reductions
- BLGCC is to prefer if we want only CO_2 emission reduction
- The conclusion is not sensitive to changes in fuel and biomass prices or choice of discount rate or marginal electricity supply.

Thank you for your attention!

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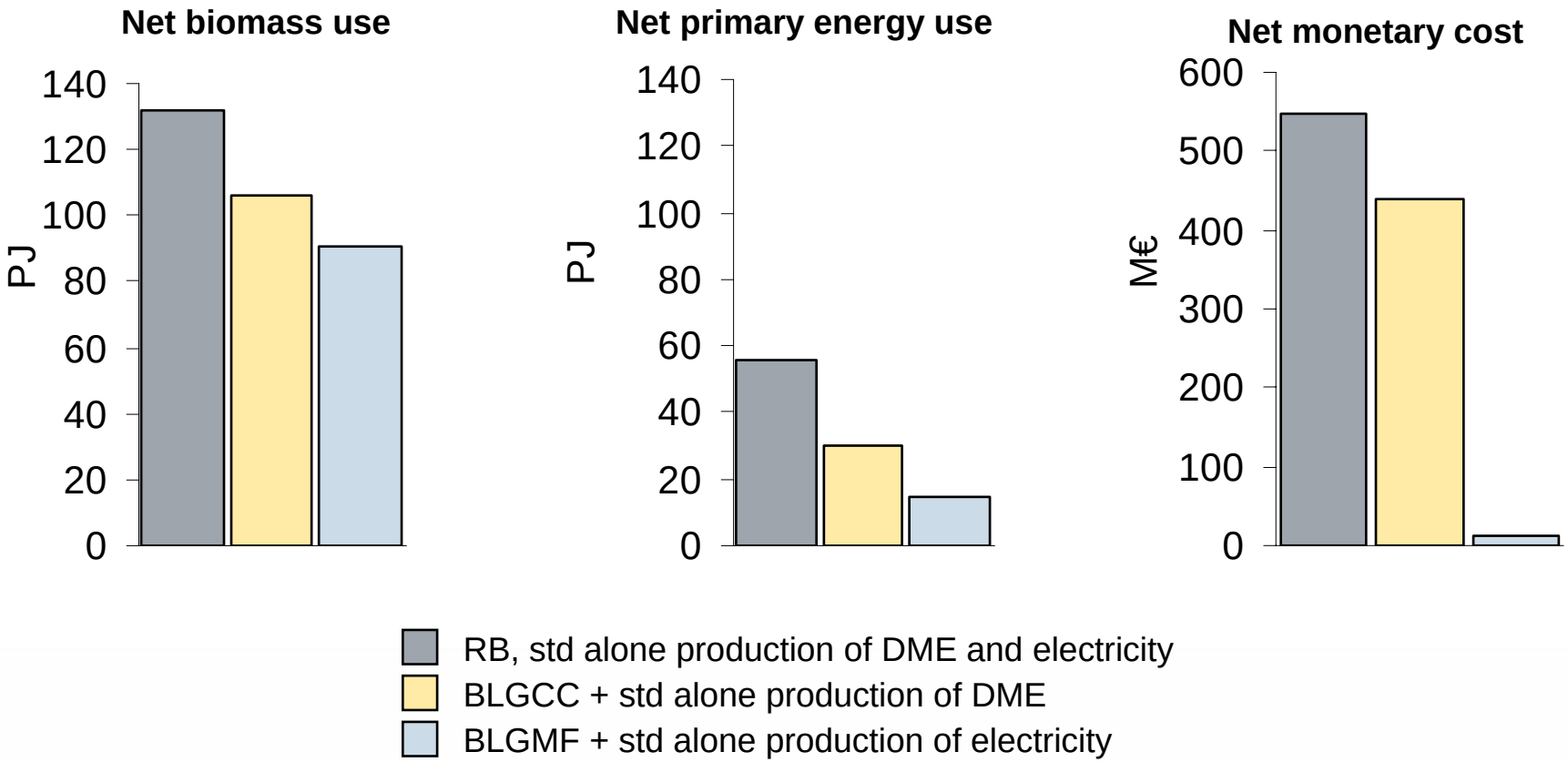
Costs to reduce Swedish CO_2 emissions by 1.6 Mt C and oil use by 64 PJ



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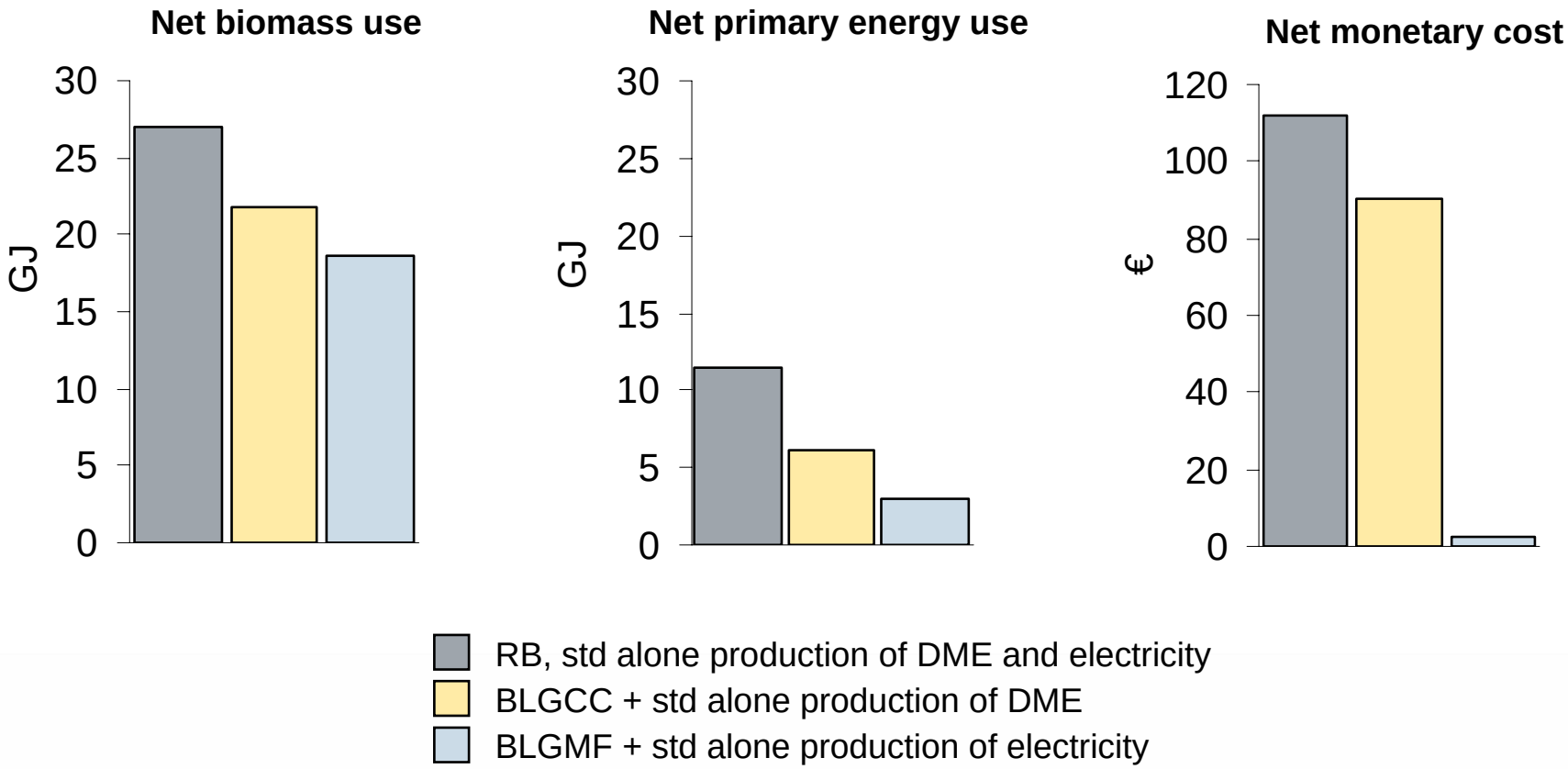
Costs to reduce CO_2 emissions by 400 kg C and oil use by 12 GJ

(reduction per tonne pulp)



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Comparison to market prices