Bio-Economy: Chances, Risks, and Perspectives for the System as a Whole

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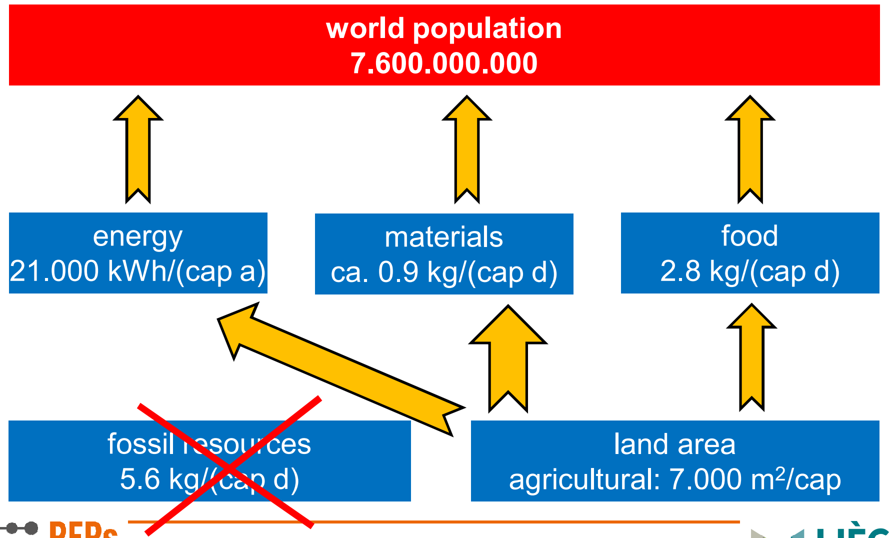
the system, scale-down factor 10 000 000

THE major driver



world population as used by IPCC

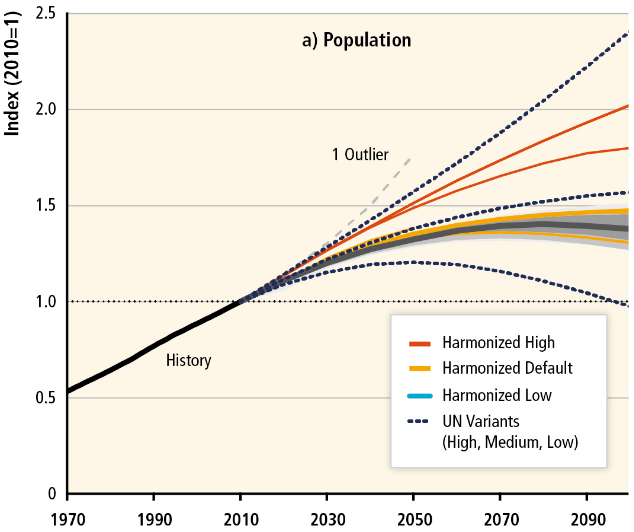
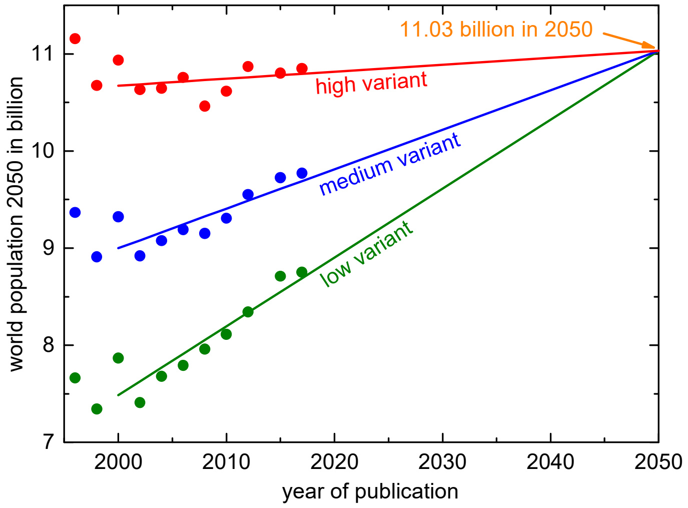


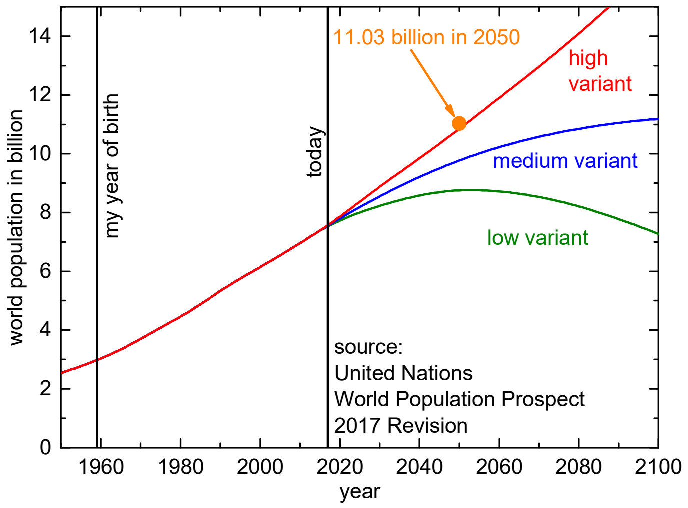
Figure 6.1, p. 425 from:
IPCC, 2014: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

based on UN World Population Prospect 2012

development of UN-WPP predicting for 2050



world population scenarios



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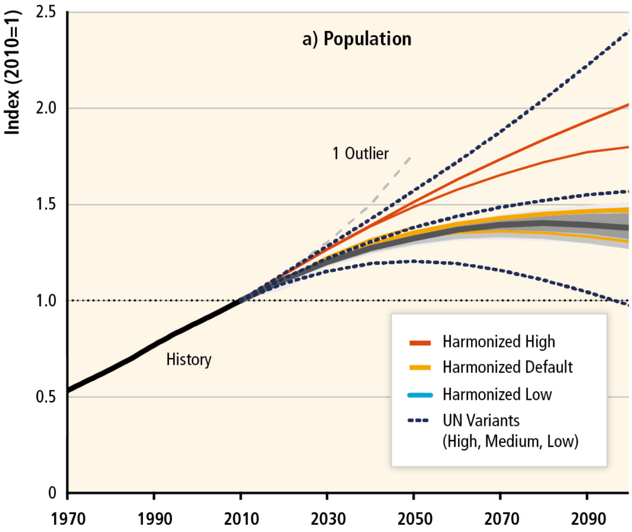

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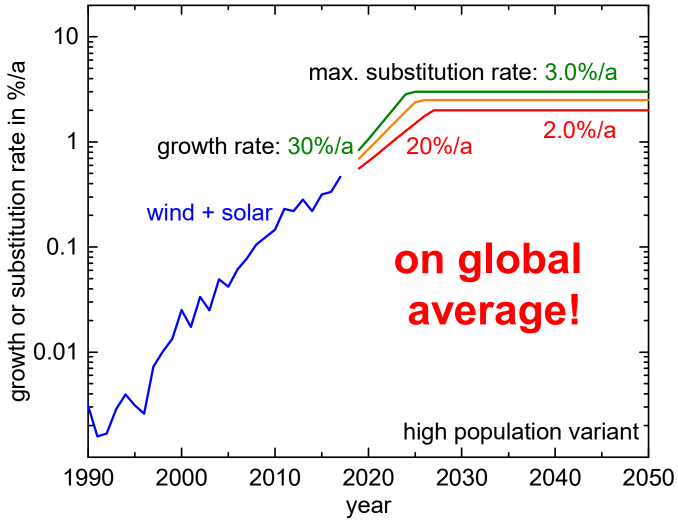
based on
UN World Population Prospect 2012

conclusion

The UN high-population variant has to be considered as realistic a scenario as the medium variant.

defining three future scenarios



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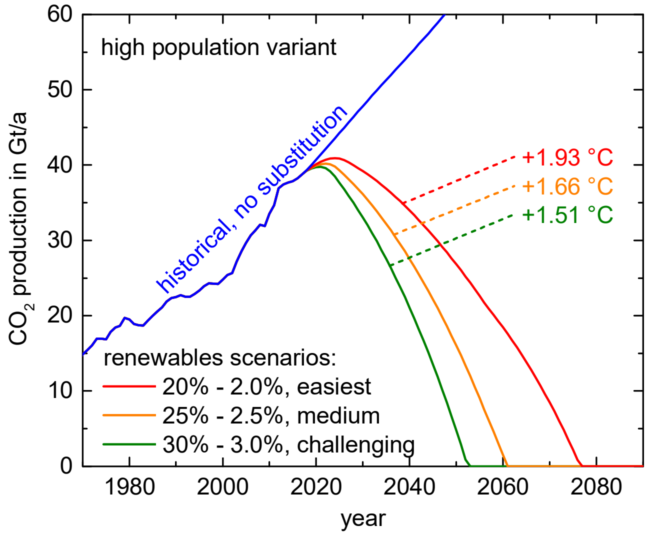
CO_2 according to three scenarios



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conclusion

time-scale: turning point in 5 to 10 years

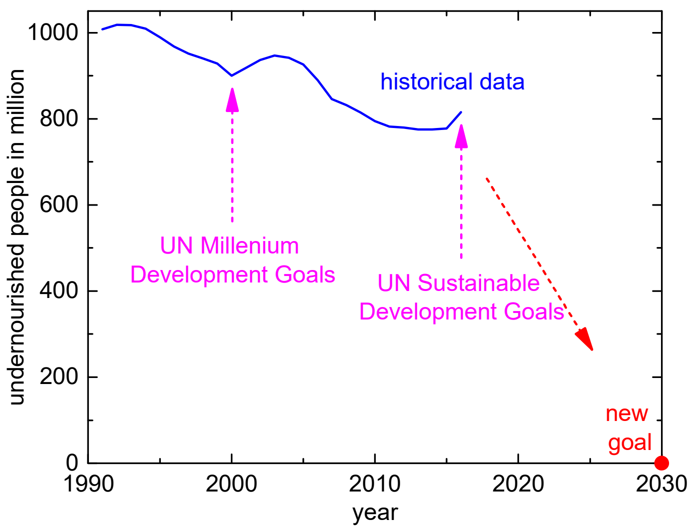
strong effect in 10 to 20 years

volatile prices of fossil feedstock foreseeable

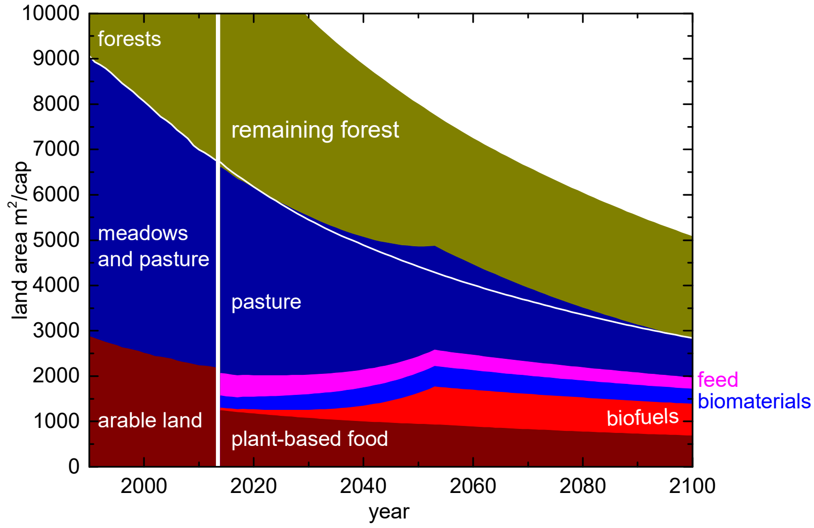
By then, bio-economy should better be well on its way!

Reducing population growth simplifies transition.

world hunger



land-area: challenging, high pop. variant



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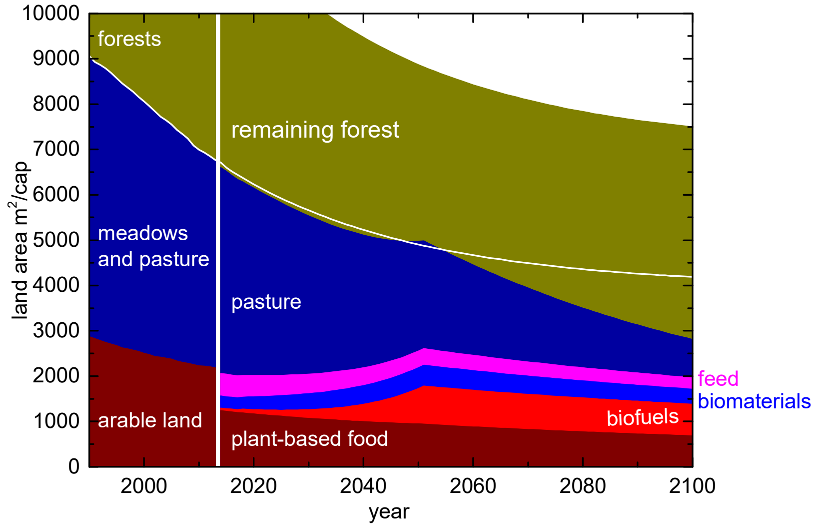
land-area: challenging, medium pop. variant



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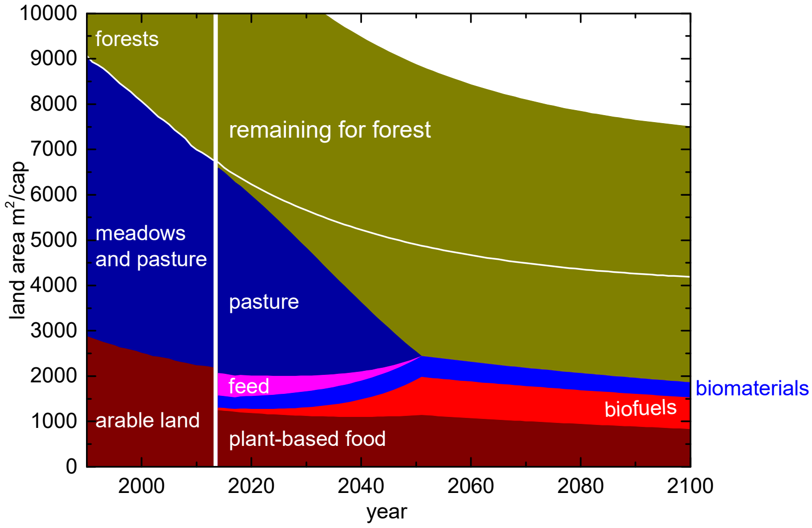
land-area: challeng., medium pop., vegetal



conclusion

No workarounds!

with behaviour change:

available technology allows sustainable wellbeing

without behaviour change:

technologies continually pushed to limits or

more people undernourished

⇒ change of behaviour essential

conclusion

To feed the world, change in behavior essential:

- **maximum 2 children per family**
- **exclusively plant-based food**

Nevertheless: competiton for land area between

- **feedstock for bio-fuels and bio-materials**
- **food production.**

⇒ land-area demand for feedstock

is essential selection criterion!

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calculation of exergy

exergy of a material stream

$$E_i = \sum_{i=1}^{N} \left(E_{i,\mathrm{chem}} + E_{i,\mathrm{phys}} \right) + \Delta E_{\mathrm{mix}}$$

chemical exergy of a material stream

$$E_{i,\mathrm{chem}} = \Delta^{\mathrm{o}} G_i + \sum_{i=1}^{j} \nu_{i,j} E^{\mathrm{o}}_{j,\mathrm{chem}}$$

physical exergy of a material stream

$$E_{i,\mathrm{phys}} = \int_{T_\mathrm{U}}^{T_\mathrm{R}} C_i(T)\,dT + V_i^{\mathrm{iF}}(P_\mathrm{R} - P_\mathrm{U}) - T_\mathrm{U} \int_{T_\mathrm{U}}^{T_\mathrm{R}} \frac{1}{T} C_i(T)\,dT$$

+ exergy losses in processes and equipment

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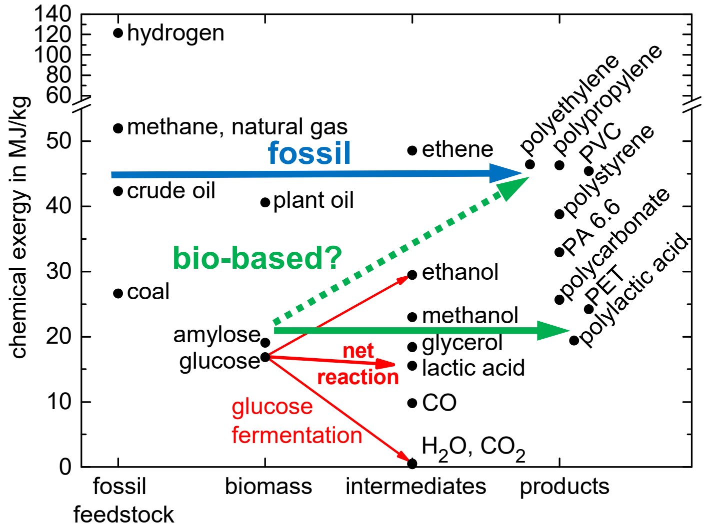
chemical exergy of various materials



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after: Philipp Frenzel, Rafaela Hillerbrand, Andreas Pfennig:
Increase in energy and land use by a bio-based chemical industry.
Chemical Engineering Research and Design 92 (2014) 2006-2015

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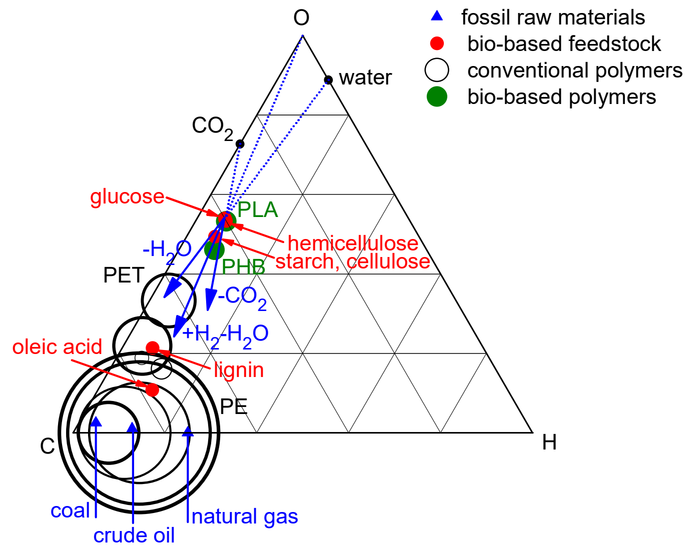
elements in chemical industry by weight



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source: Philipp Frenzel, Rafaela Hillerbrand, Andreas Pfennig:
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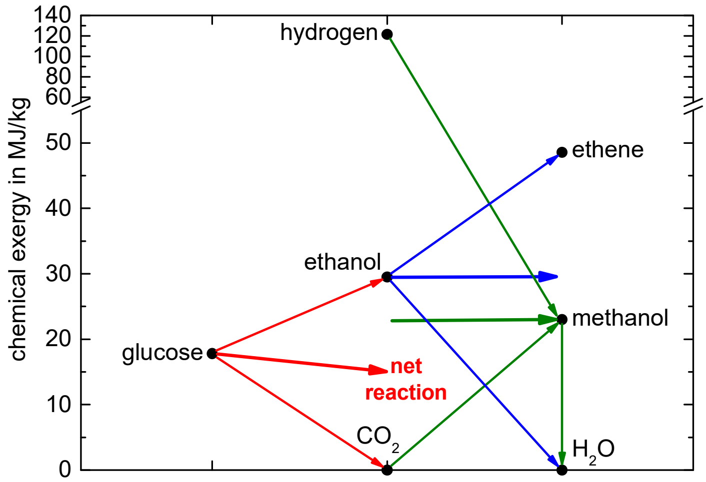
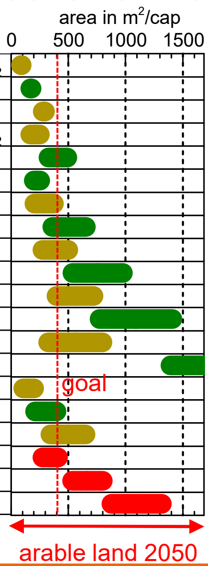
feasible reactions



options for bio-based chemicals

gen.	feedstock	products
1	sugar cane	sugar or ethanol + CO_2
		ethanol
		ethylene
1	sugar beet	sugar or ethanol + CO_2
		ethanol
1	oil palm	plant oil
1 + 3	corn + straw	ethanol + CO_2
		ethanol
1	corn	sugar or etanol + CO_2
		ethanol
3	corn straw	ethanol + CO_2
		ethanol
1 + 3	wheat + straw	ethanol + CO_2
1	rape seed	plant oil
2	miscanthus/reeds	ethanol + CO_2
		ethanol
		ethylene
2	wood	ethanol + CO_2
		ethanol
		ethylene



ranges:
maximum national and world average productivity projected for 2050

color:
- technically realized
- partly pilot-plant
- lab-values or complex

in radius 50 km:
200 m^2/cap >600 000 t/a
400 m^2/cap >300 000 t/a
600 m^2/cap >200 000 t/a

conclusion

- solely third generation bio-processes not feasible
- first and second generation compete for same land area as food
- various options available as feedstock:
  sugar cane, sugar beet, corn, palm oil, miscanthus/reeds
- preferably either sugar chemistry or utilization of CO_2
- cellulose utilization is add-on benefit, but large by-prodcuts
- strong interaction:
  agriculture ↔ food ↔ chemistry ↔ energy

chances, challenges

- biobased chemistry: various options
- bio-economy ≠ only bio-technology
- bio-economy ≠ automatically sustainability
- technology ↔ human behavior
- economics, ecologics, **ethics**
- **big chance**: real circular economy
- all happens in ±30 years (or it will be too late)

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