THE RATIO BEHIND TORREFACTION

trade off between additional invesment & energy use vs. logistical & end user advantages

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What characterises the solid biomass for power market today

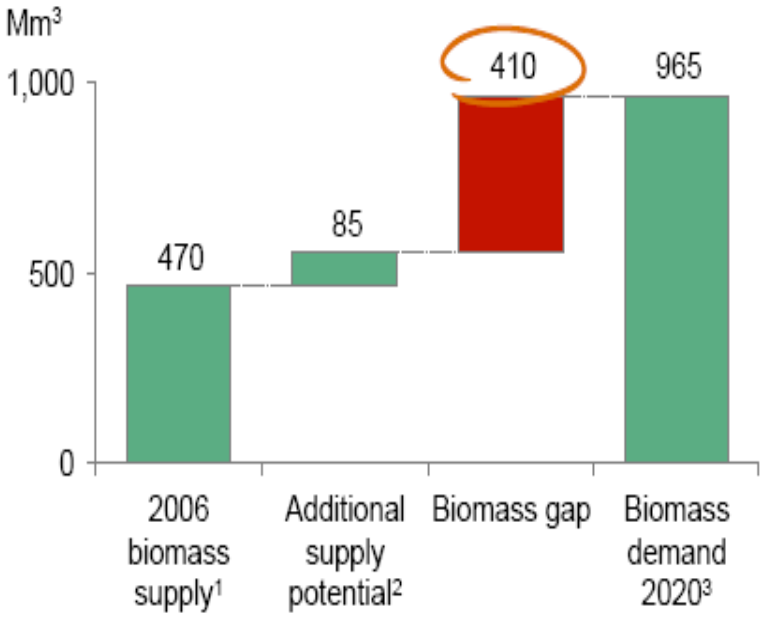
- Costs of Biomass still above conventional energy carriers
- Resulting dependence on political decissions
- Starting competition for woody raw material
- Investment barrier for users – technology
- Imaturity
- Limited Liquidity
- Lacking of the one perfect commodity to lead the market

What would speed up the growth

- Increased cost competitiveness
- Possibility to use established technology for conversion into Heat/Power
- Better storability of product
- Development of commodity status
- Further upgrade and homogenization of the diverse solid biomasses

Is there sufficient Biomass for further growth

Estimation of EU 27 woody biomass gap 2020



Green-x based Pöyry Study[4] predicts gap of ~ 350Mm³

Potential alternatives to bridge the gap

Recovered wood
- Discarded furniture
- Construction wood

Short rotation crops
- Miscanthus
- Willow, Poplar

Import of biomass
- Sourcing from e.g. Russia or North America

A gap of 350–410Mm³ woody biomass has to be closed in the EU

Source: BCG

Given this Framework where is Torrefaction coming in

- Torrefaction is addressing most of todays shortcomings in the biomass for power market contributing very positivly
- Decreases investment requirement at users by this increasing flexibility tremendously
- Will help to bring in all kind of underutilised biomasses to the market
- Will increase liquidity of the biomass market

Say intentions come true

- Torrefaction will turn the whole solid biomasses market upside down
- Consumers will procure TCB not only for ist CO_2 neutrality but also to diversify resources to increase security of supply
- The market will grow enourmously
- Europe will lose its position as pace maker of the global Bioenergy market
- Enormous resources will become accessible

Pros / Cons on Torrefied Compacted Biomass (TCB)

1. Increases feedstock basis
2. Decreases costs on storing and transporting
3. Reduces biodegradation of product close to 0
4. Consumes less energy in preparation
5. Reduces investment need at user
6. Made to measure resulting in increased co-firing ratios
7. Will build commodity status
8. Large variety of applications

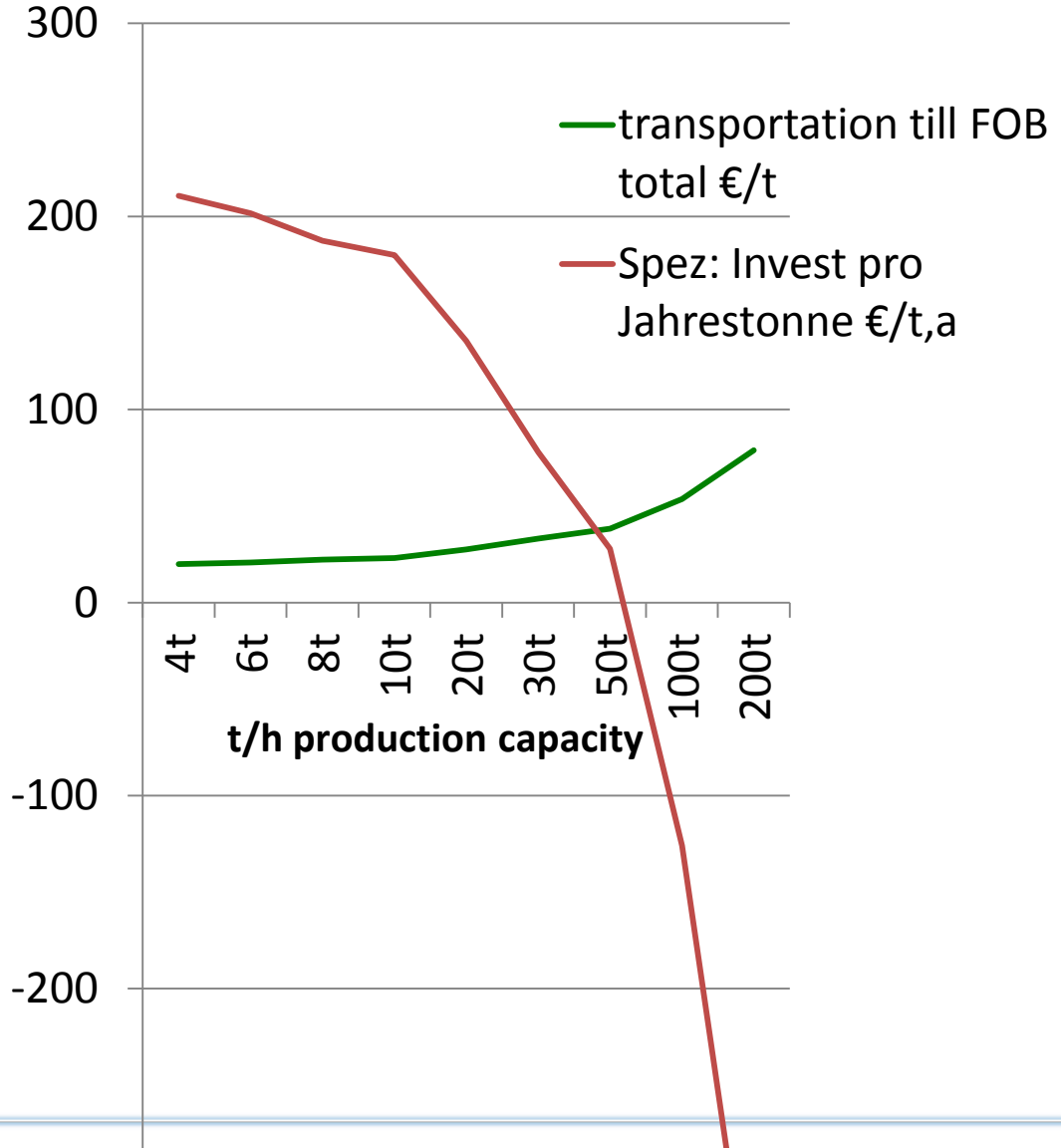
1. Increased energy consumption in production
2. Might camouflage origin of raw material
3. Contributes to globalisation of market (con?)
4. If improperly produced causes emissions
5. Any further?

Increases feedstock basis

- Wood residues
- Agricultural (by)products
  - –straw
  - –miscanthus
  - –FFB
  - –Grass/Hay
  - –Bagasse
- Other solid Biomasses
  - –Bark
  - –Nutshell, Husk

Literally every solid biomass can serve as input material and produce acceptable results

Sizing of TCB production sites

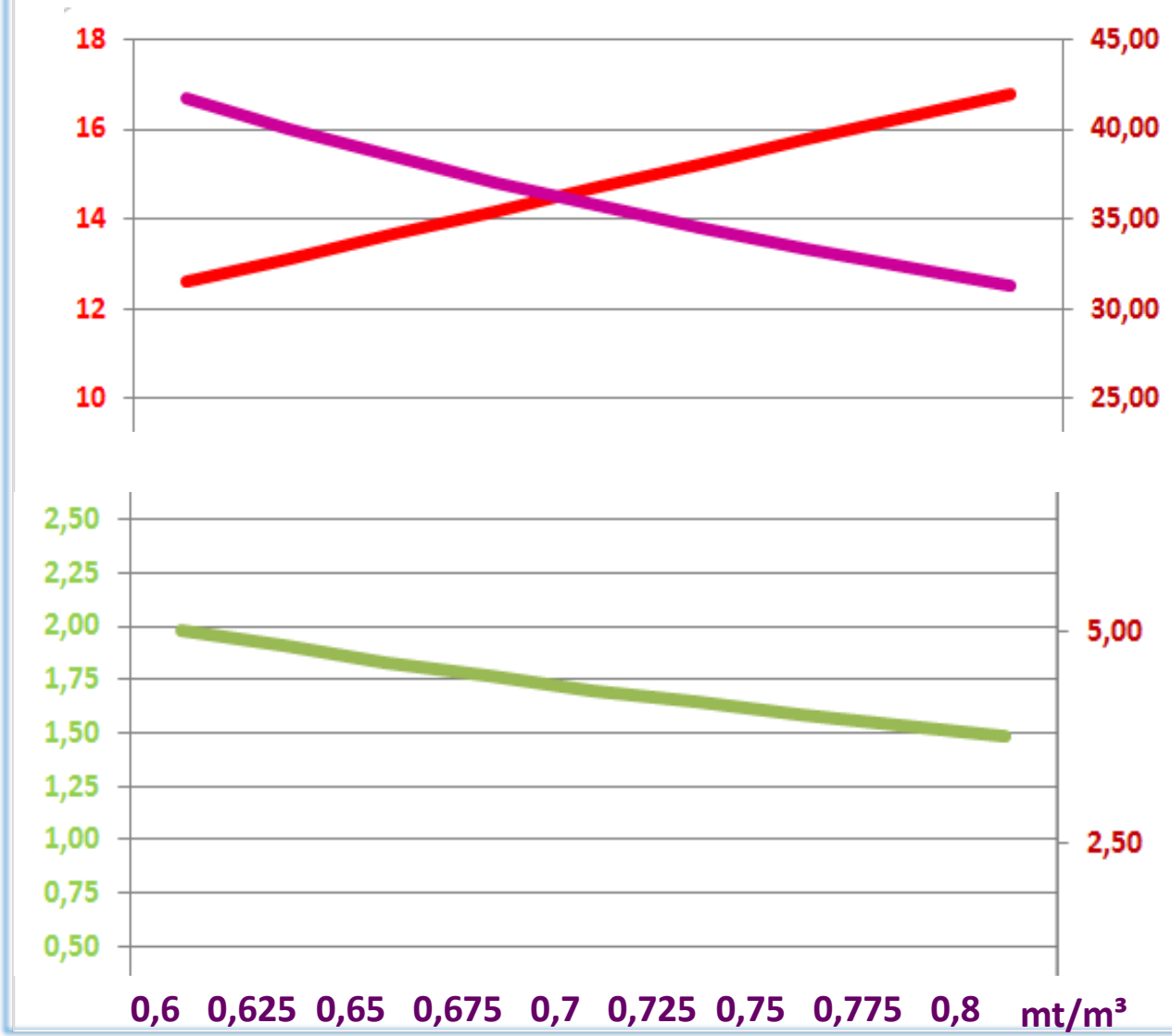


Can economies of scale compensate for higher transportation cost on raw material?

No, they can´t

Large TCB units only for by-product torrefication

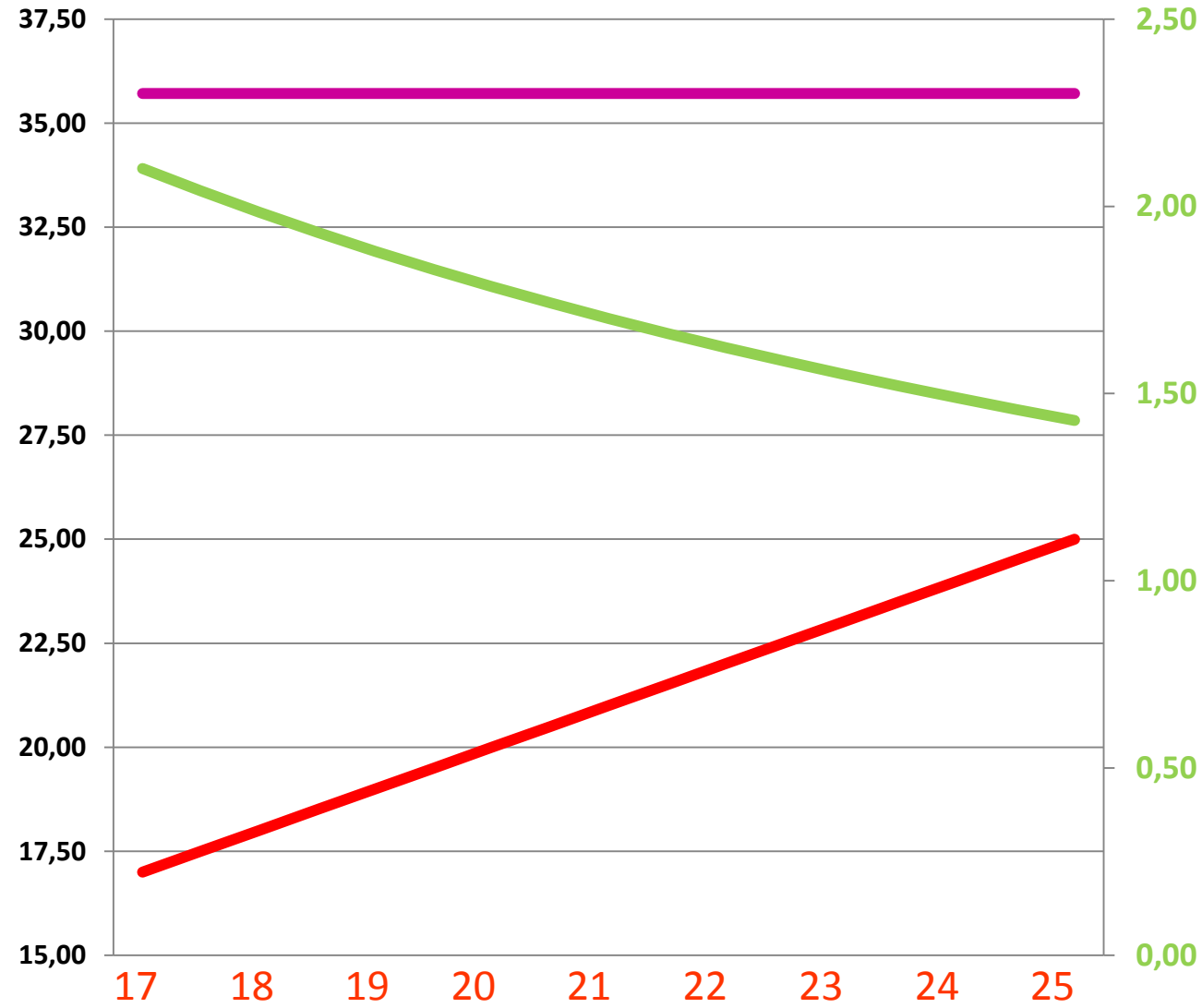
Reducing costs on storing and transportation



Assumption:
NCV - 21GJ/mt
Freight - 25US$/m³
Densification variable

Energy content GJ/m³
costs shipping US$/GJ
costs shipping US$/mt

Reducing costs on storing and transportation



Assumption:
NCV - variable
Freight - 25US$/m³
Density 700kg/m³

Energy content GJ/m³
costs shipping US$/mt
costs shipping US$/GJ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Reduced costs in storing and preparation for combustion

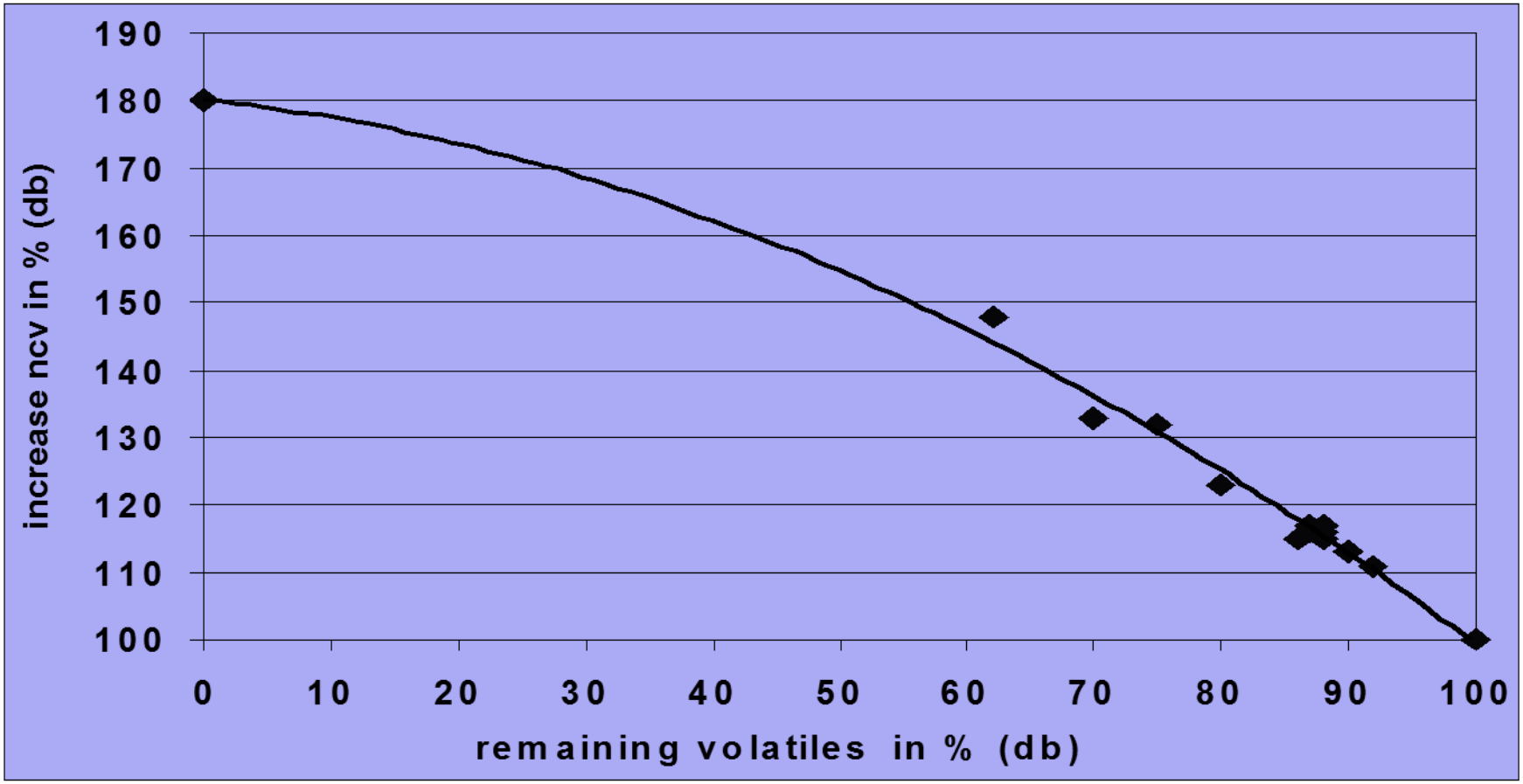
- TCB can be pulverized similar to coal
- Particle size of 400 – 100 µm achievable
- 7.5 to 15 times the energy to grind untreated wood similar

	Hardgrove Index
Wood Chips	15-20
PKS	17-22
Wood Pellets	20-30
TCB	40-60
Coal	40-80

- TCB -stored with coal and no problems to co-mill for a pulverized coal boiler
- Wood pellets require to be stored, ground and fired separately-extra costs estimate 2 – 3 €/mt

Sources: EBES, ECN, G. van Bommel, R. Walton,

Made to measure

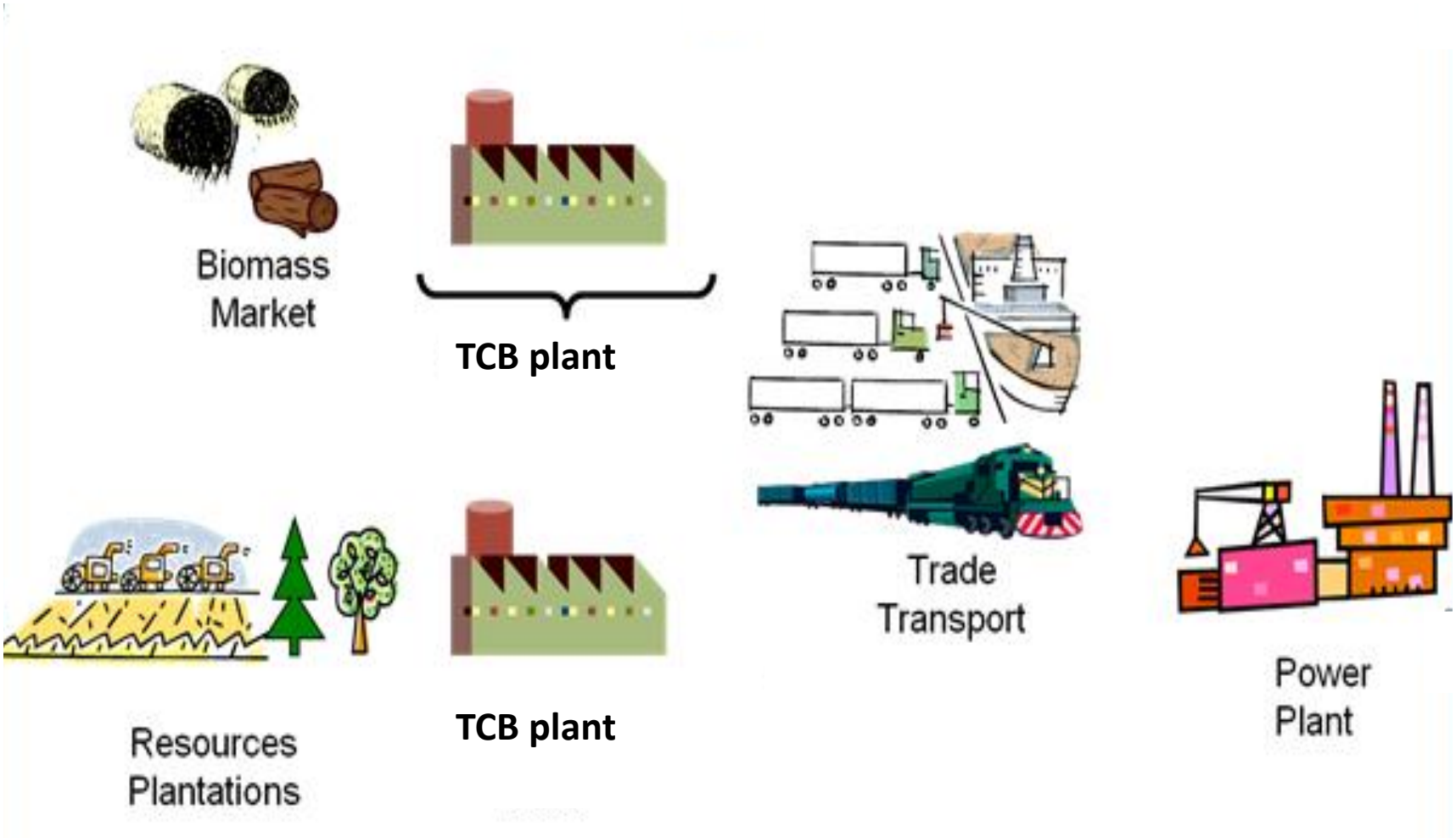


- Increased co-firing rate expected
- Plenty of applications to substitute carbon from coal

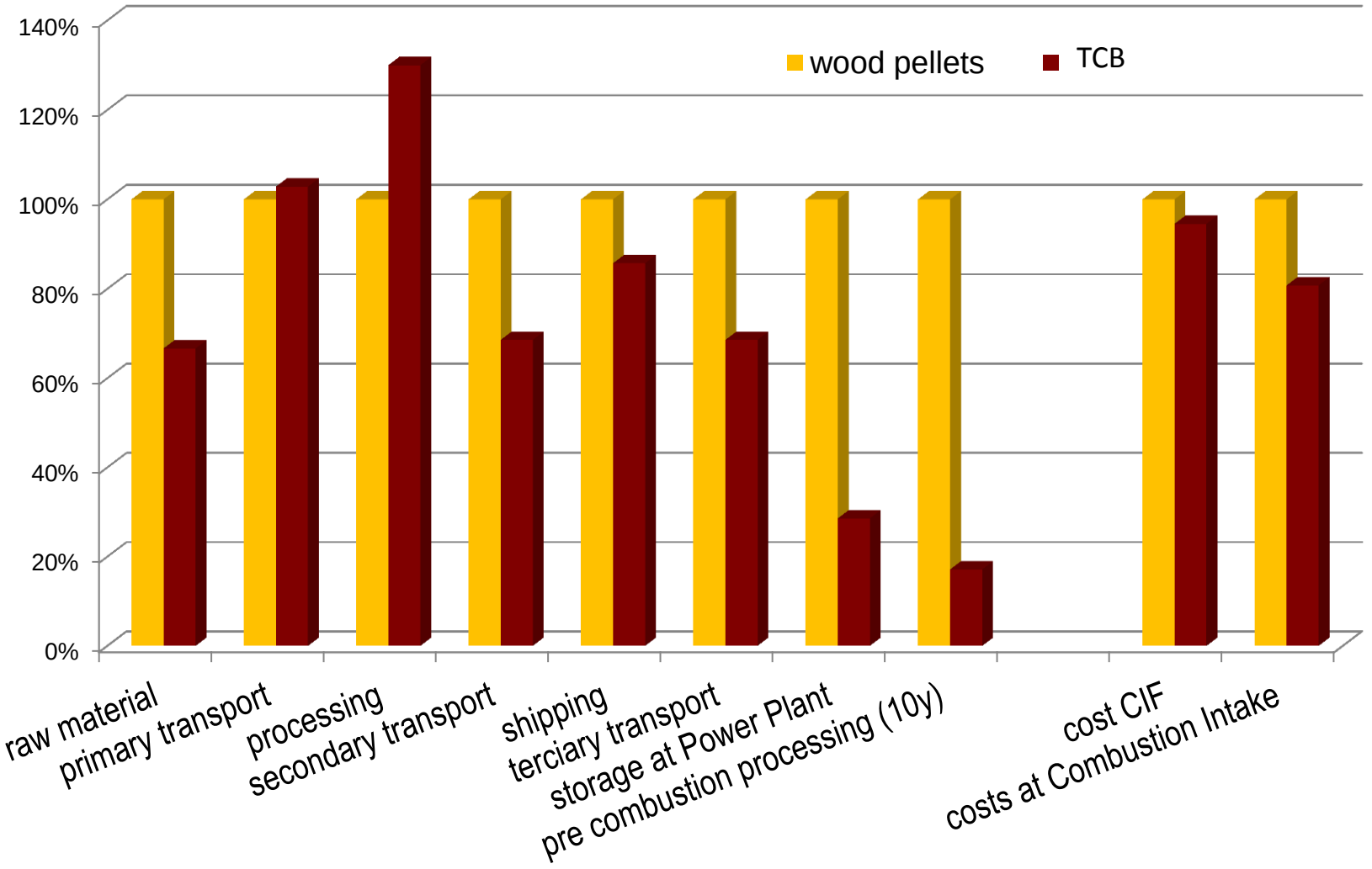
First real Commodity?

- Torrefaction will homogenise the divers biomasses better than any other technology today
- Torrefaction will enable producers around the globe to produce aequivalent product
- some cost factors are equivalent to costs in coal chain
- Hedging contract risks will become easier

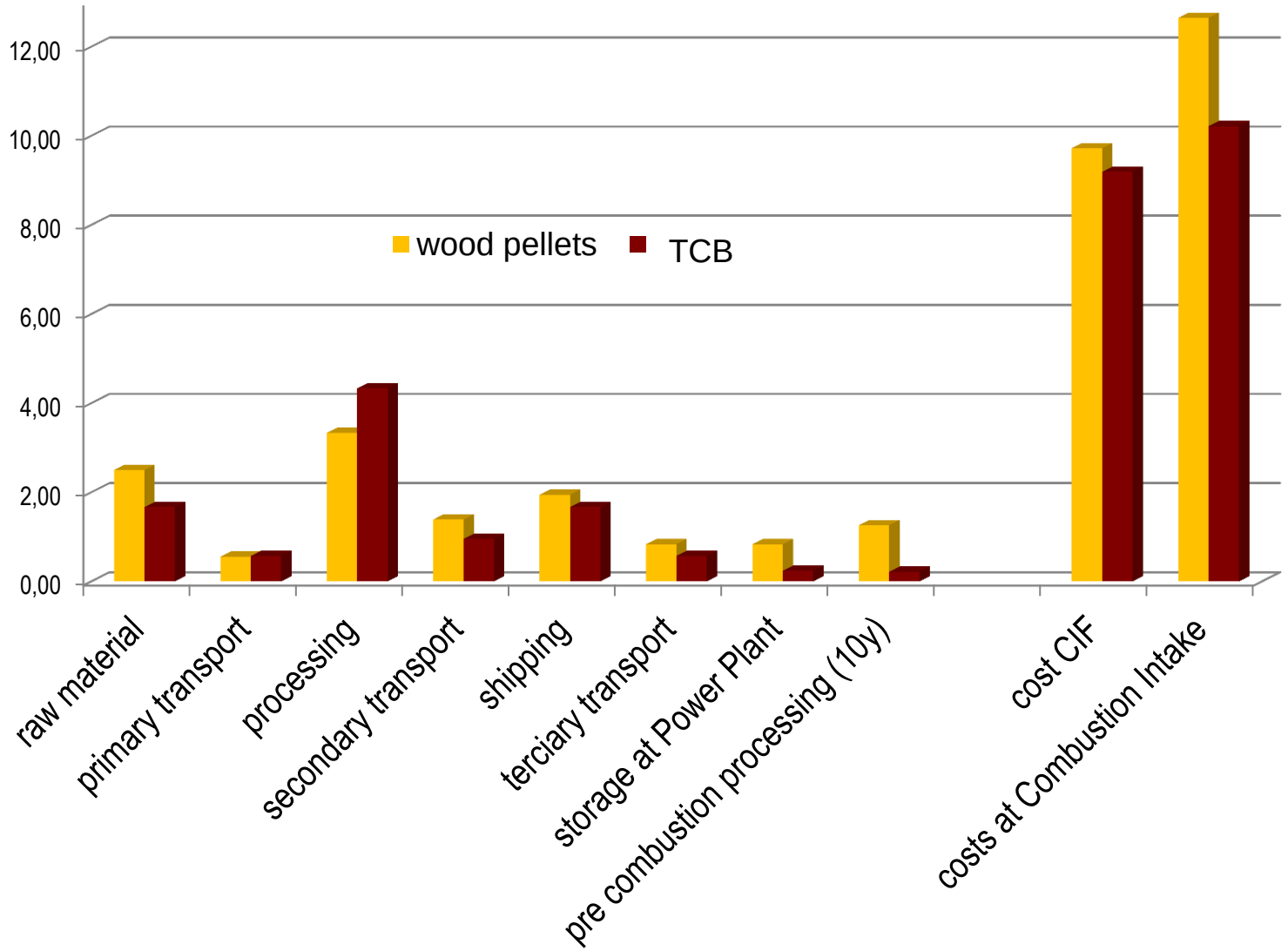
Effects within the value chain



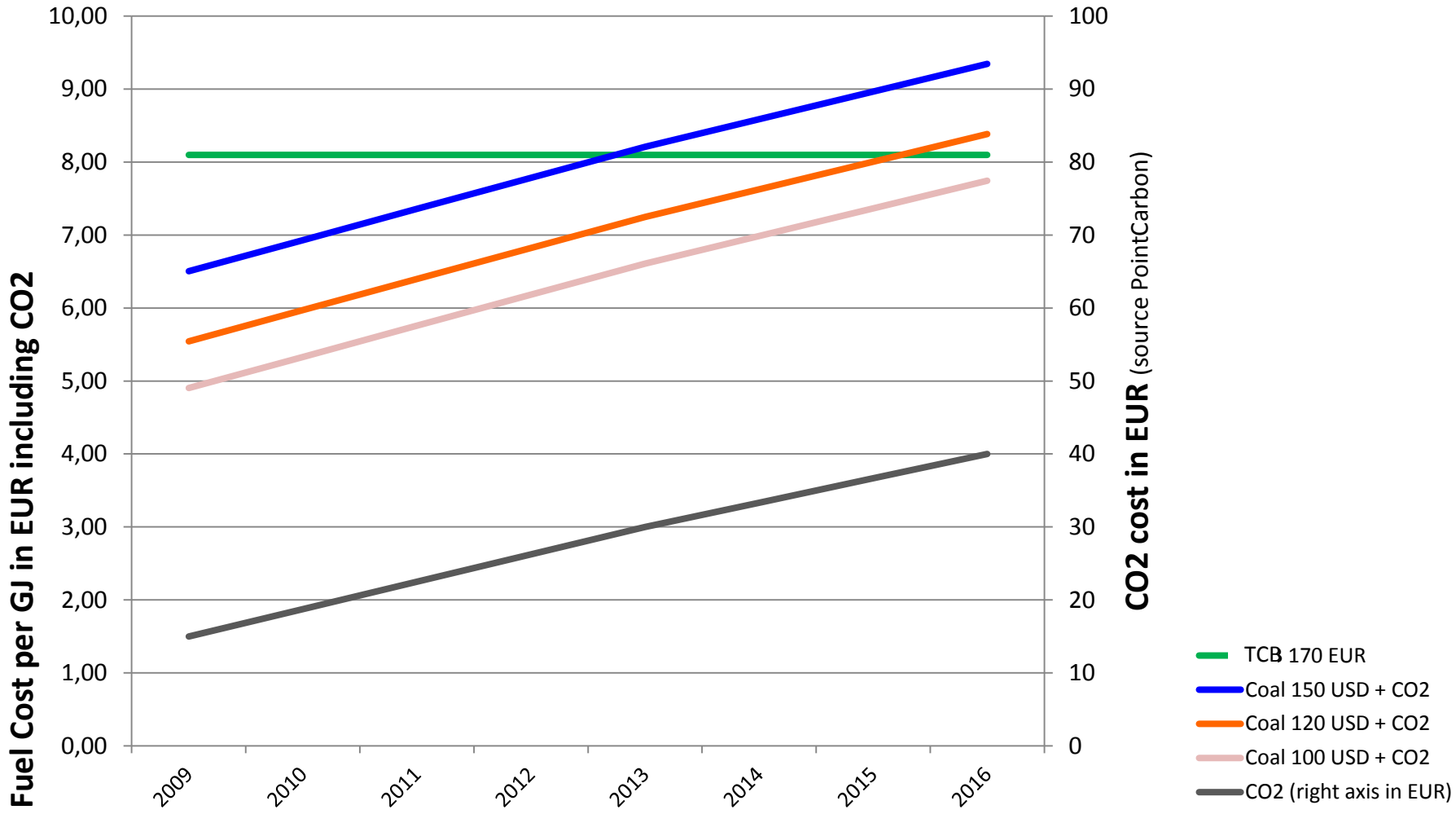
Cost Comparison



Cost comparison US$/GJ 2010 CIF ARA



TCB ever to compete coal directly?



Motivation for co-firing

- Highest Efficiency in Biomass to Power conversion
- Modest additional investments required

  (50-250 €/kWel with wood pellets, much less with TCB)
- Reduction of CO_2 NO_X and SO_XEmissions
- Reduction of needs for ash treatment achievable
- Diversifikation of Fuel Basis
- Green Image in PR
- Significant Profit Opportunities

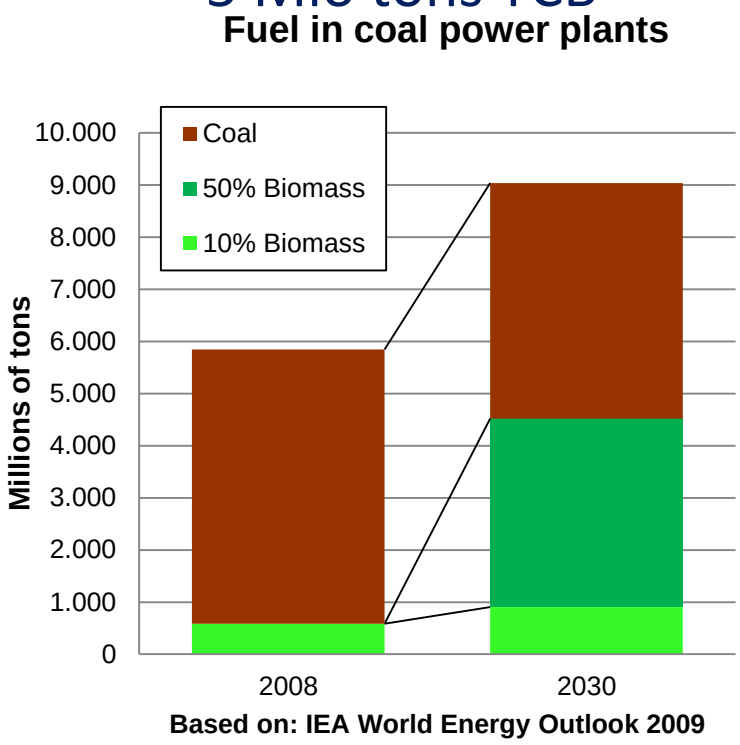
Market Potential Co-firing

1 typical 2000MWe Power Plant requires :

10% co-firing as common — 1 Mio tons TCB

50% min technically possible — 5 Mio tons TCB

- ≥ 200 Mio € turnover /power plant
- 2850 power plants world wide
- Market is open globally
- Main players at demand side: China, India, Europe, Japan, USA
- Opening the opportunity of fuel diversifikation



Further Markets

- Gasifikation
- Steel Mills
- Heating
- Fertilising

This list is not claiming to be complete

Open Issues

- Still no technology available for global roll out
- Is the topic of densification (pelletising) solved
- All expected advantages to be proven when large volumes are available
- Security issues can not be tackled sufficiently today
- Co-combustion behaviour in large scale not tested sufficiently

This list is not claiming to be complete

Conclusion

- There is an enormous need for TCB to turn into demandonce technology is ready for roll out
- Torrefaction is the means to turn the biomass for power market upside down
- Cost advantages support uptake further
- Supply chain efficiency to increase
- Extreme growth rates of the market can be expected once expectations in quality are proven in large scale testing
- Let‘s go for it

Thank you for paying attention

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