

**First workshop of the Crops2Industry Project.
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Land Use Competition for Food, Feed, Fuel and Fibre production

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“Feeding the world”

“If the world is to have enough food to feed an estimated 8-9 billion in 20-30 years time, significant changes and hard policy choices will have to be made.

Productivity needs to be dramatically increased, but climate change and the increased scarcity of resources, including land, water and phosphate, and the variability of energy and other input costs, will present challenges to the collective ability to produce additional food.”

So if land will become scarce for food supply, how can we also move towards a future bio-economy?

All land is multi-functional -

- **Production – food, timber, feed, materials, energy, fibre.**
- **Water cycling – catchment, filtration, flood control.**
- **Carbon storage – stocks, sinks, emissions from soil and biomass.**
- **Biodiversity – habitats, genetic diversity, species.**
- **Landscape and cultural heritage.**
- **Recreation and inspiration.**

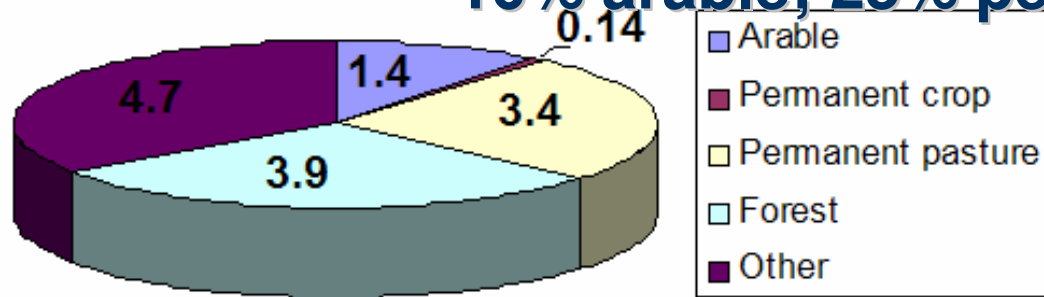


Land area breakdown

World

Billion hectares

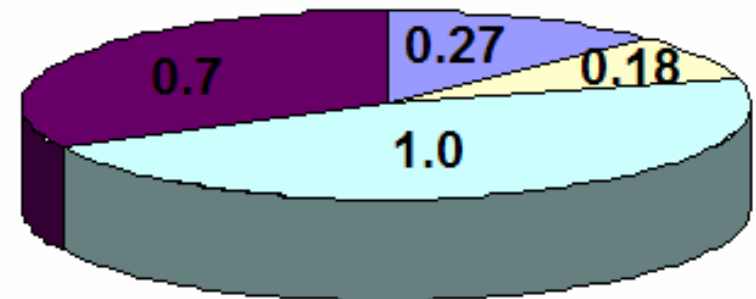
10% arable; 25% permanent pasture



European Union

13% arable; Billion hectares

8% permanent pasture



FAO Stats



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What aspects of land use and management are least sustainable?

- **Impacts on water resources.**
- **Losing soil C and fertility.**
- **Reliance on fossil fuel product inputs.**
- **Loss of biodiversity showing an unhealthy environment.**
- **People losing contact with the land.**
- **Diminishing public benefits.**



Land use and productivity

Theoretically 5% of the Earth's land would be sufficient to meet the total global energy demand, given a 1% conversion of sunlight into biomass.

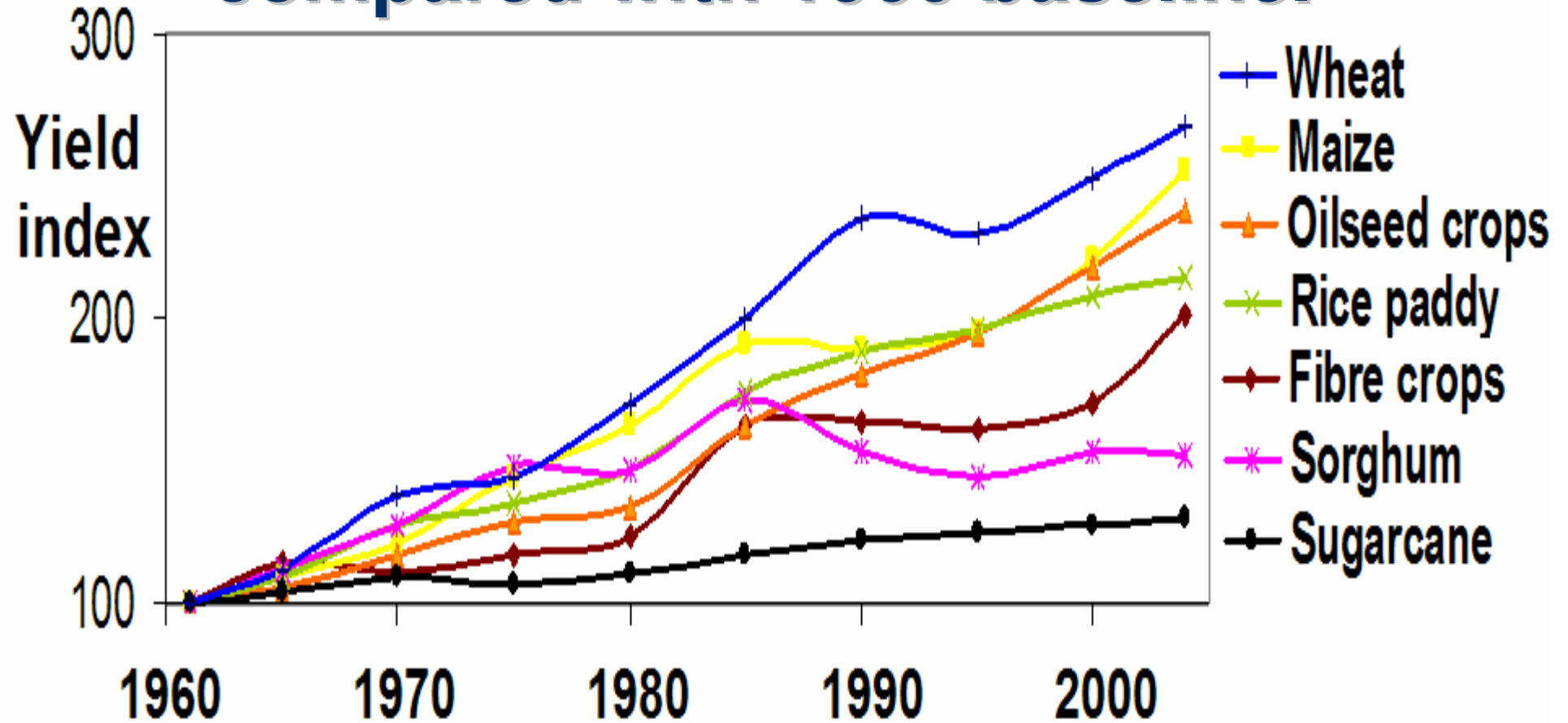
Some say limits to conventional crop yields could be around 30 t dry matter in Europe and 50 tdm in tropical regions.

Yet yields up to 400 tdm are being contemplated for "energy cane" in Brazil.

So what is the "maximum" crop yield?



Worldwide average crop yield trends compared with 1960 baseline.



**Can increases in crop yields continue?
Will production be even less sustainable?**



Crop production can be increased by:

- **expanding the available cropped area;**
- **increasing cropping frequency – e.g. by irrigation in the dry season;**
- **boosting yields – by plant breeding, crop management, reduction of post-harvest and supply chain losses.**

Are we approaching the limits of all three?



The “Cologne Paper” - On route to the Knowledge-Based, Bio-Economy

- **A giant leap in agricultural yield – at least by a factor of 2 to 3 – will be needed within the next two decades.**
- **This must be achieved in an ecologically sustainable way.**
- **Green technology will be employed since conventional breeding will not be sufficient.**
- **Conflicts resulting from limited land need to be solved by innovation and efficient regulation on an international level.**



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Crop production systems by 2030

- **Efficient irrigation and water supply management offsets water constraints**
- **Genetic modification and breeding programmes result in higher yields/hectare**
- **Supply chain and post-harvest improvements give less losses.**
- **Decline in deforestation.**
- **Semi-arid and marginal lands better utilised.**
- **Impacts of climate change – droughts etc.**
- **Societal changes result in –**
 - **reduced food waste**
 - **less demand per capita for animal protein**
 - **population stabilisation around 9 billion.**
- **Capacity building in Africa, S America etc.**
- **Precision agriculture reduces inputs.**



How much land will become available in the future?

- **Future supplies hard to determine.**
- **Crop and forest residues and animal wastes are cheap and easy to assess.**
- **Waste-to-energy resources are limited.**
- **Sustainable production of biomass from energy crops is under scrutiny.**
- **Potential of GM crops is unknown.**
- **Land available for energy crops will depend on future farm management regimes and crop yield increases.**



Passion Cereales, France.

Cereal production changes

- **Fertiliser /ha reduced 60% 1990-2006.**
- **Water consumption reduced 20-30% by improved irrigation 1995-2005.**
- **Agri-chemicals reduced 21% 2001-2008**
- **Yields up 15-20% 1990-2006**

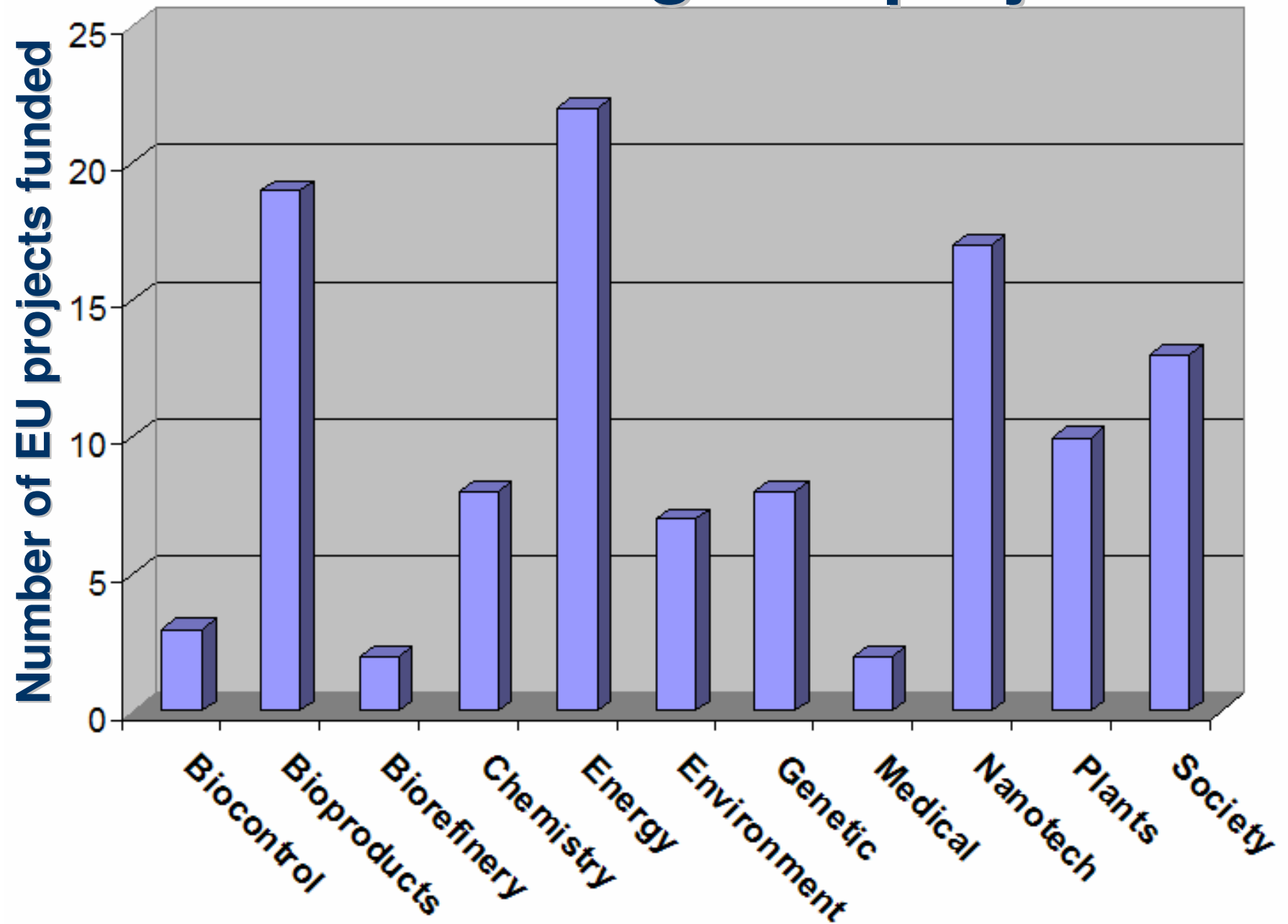


Earlier non-food research in Europe 1988-2008 – EPOBIO report 2007

- The EU is heavily dependent on fossil C.
- Aim is to replace this with fixed C from photosynthesis in agricultural products.
- There is opportunity to substitute oil-based products with natural products and to bring new bio-products to market.
- 321 projects were funded under FP5 and 112 with a biological content under FP6.
- BUT where will all the required biomass raw materials come from for this widening range of products reaching the markets?



FP6 “Biological” projects



Fibre production from crops.

- UK studies undertaken in 1994!

- **Compared with existing fibres, is a lower cost or improved quality needed to gain market share?**
 - **Substitute for existing natural fibre products (pulp, panel boards, textiles).**
 - **Substitute for existing man-made fibres (textiles, composites, tensile products, thermal insulation, pollution clean-up) .**
- **How much do the properties of specific plant or animal fibres differ?**
- **What is the suitability of a given fibre crop for any particular application?**
- **How much needs to be grown to make a processing plant economically viable?**



Selection between fibre applications.

- **Yield per hectare.**
- **Investment in processing plants.**
- **Relative market values:**
 - **Wood fibre** **\$ 150/t**
 - **Textile fibres** **\$ 300/t**
 - **High matrix fibres** **\$ 500/t**
 - **Wool fibres** **\$1500/t**
 - **High grade textiles** **\$3000/t**



Some fibre crops with potential?

- **Cereal straw** **0.5-1 t/ha fibre**
- **Flax** **1-2 t/ha**
- **New Zealand flax** **3-4 t/ha**
- **Hemp** **2-3 t/ha**
- **Nettle** **1-1.5 t/ha**
- **Milkweed** **0.1-0.2 t/ha**
- **Miscanthus** **1-3 t/ha**
- **Canary reed grass** **0.5-1 t/ha**



Issues to consider

- **Farmer willingness to grow perennial crops.**
- **Harvesting equipment availability.**
- **Handling and storage logistics.**
- **Land ownership and employment.**
- **Competition for the “best” use of biomass-**
 - **Materials**
 - **Chemicals**
 - **Energy**
- **Greenhouse gas emission impacts.**
- **Indirect land use change impacts.**
- **Future trade in biomass and products**





Biomass trade

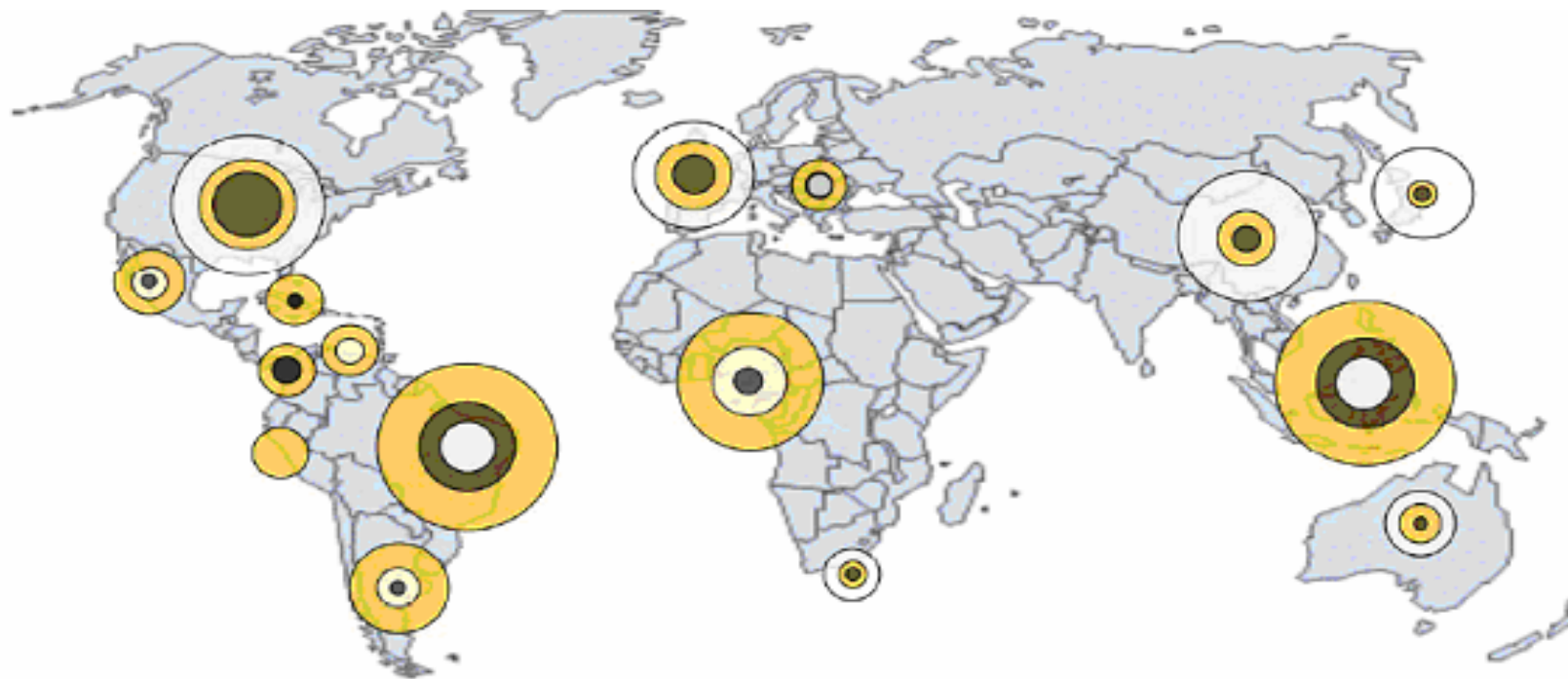
A regime for the growing trade of solid biomass (pellets, chips) and liquid biofuels is needed.

Adoption of sustainability criteria in the international arena would need to be a part of this process.



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Sustainable Biofuels Consensus Rockefeller Foundation Centre, Bellagio.



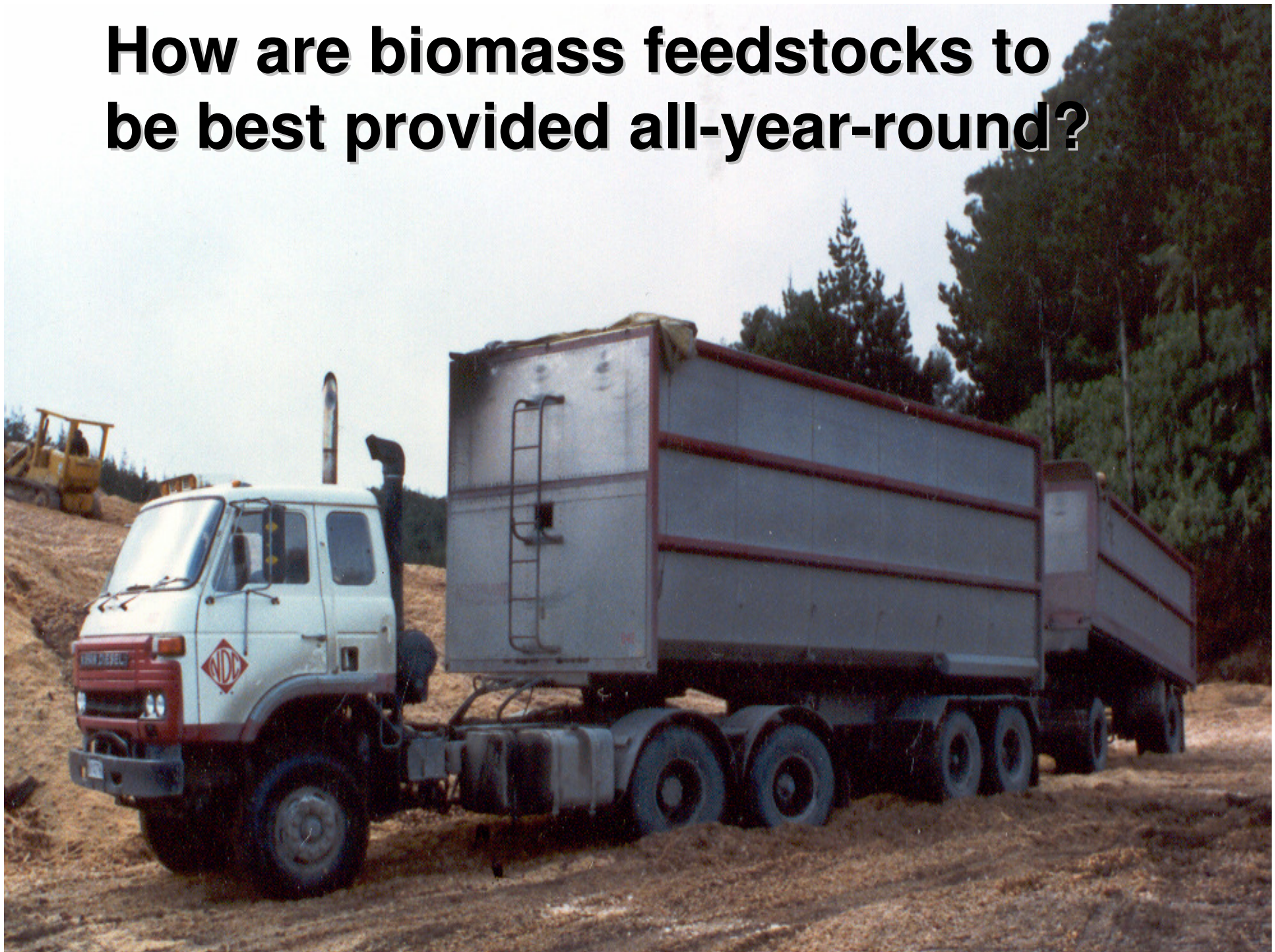
- Feedstock potential based on land available for devotion to first generation biofuel feedstocks.
- Theoretical biofuel demand, assessed to be ~30% of liquid transport fuel consumption in 2006.
- Biofuel production capacity in place at year end 2006.

- Feedstock potential exceeds biofuel demand and surplus production capacity - so export.
- Capacity less than biofuel demand so investment in infrastructure warranted to encourage export potential.
- Feedstock constrained and capacity less than demand - so import.

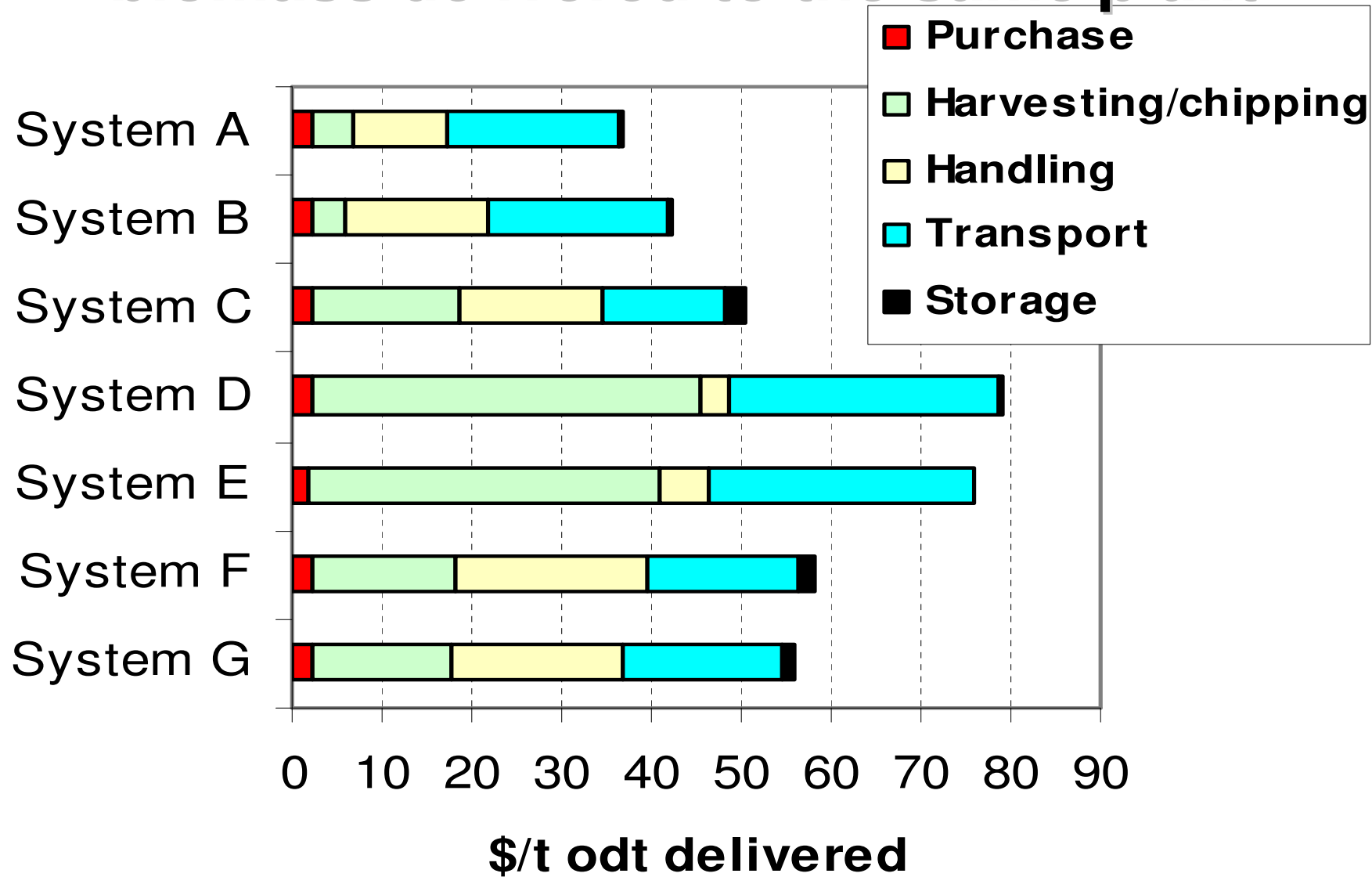
Source: New Energy Finance www.newenergyfinance.com

www.renewableenergyworld.com/rea/news/reinsider/story?id=52328

How are biomass feedstocks to be best provided all-year-round?



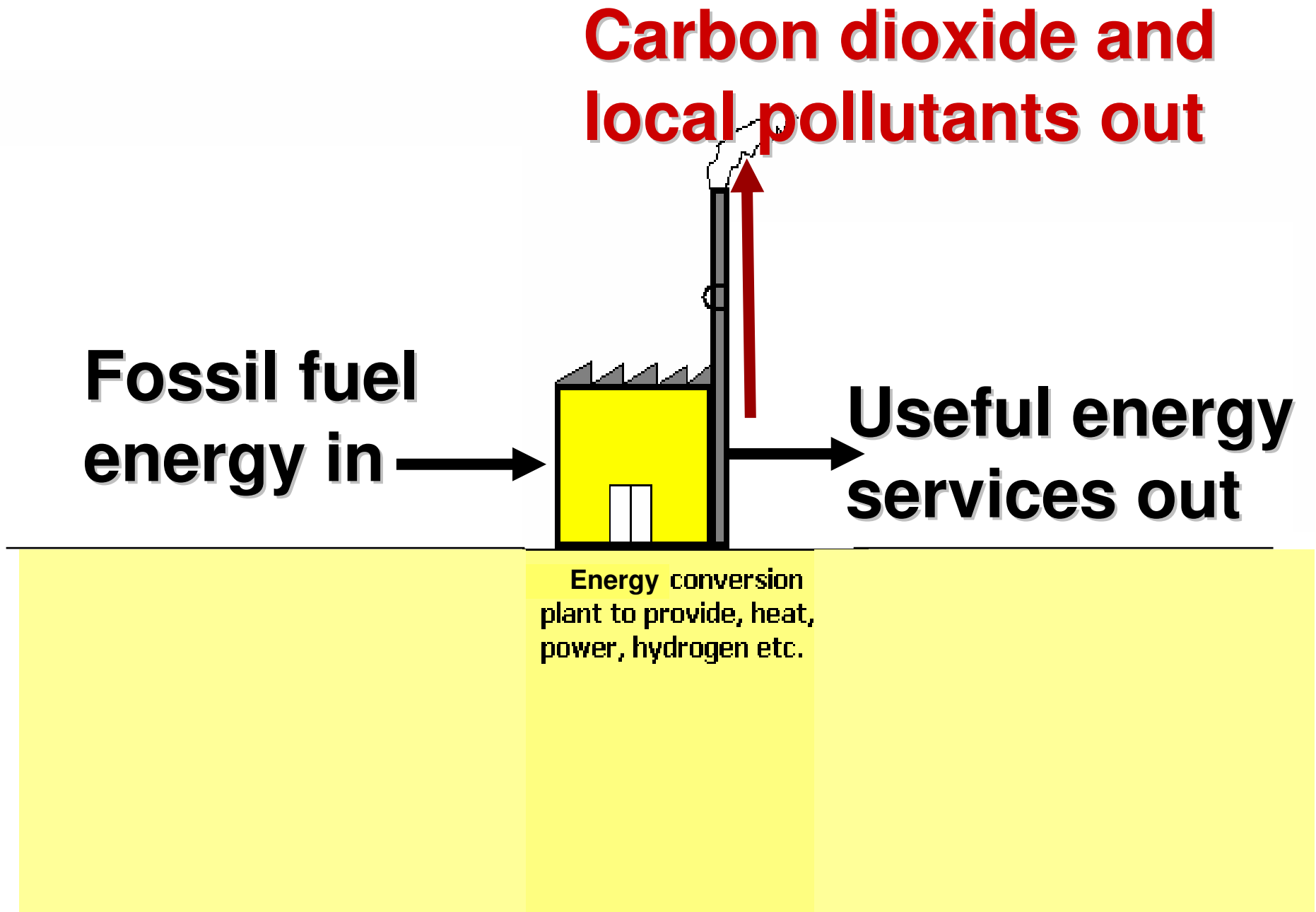
Example of variations in supply costs for biomass delivered to the same plant.



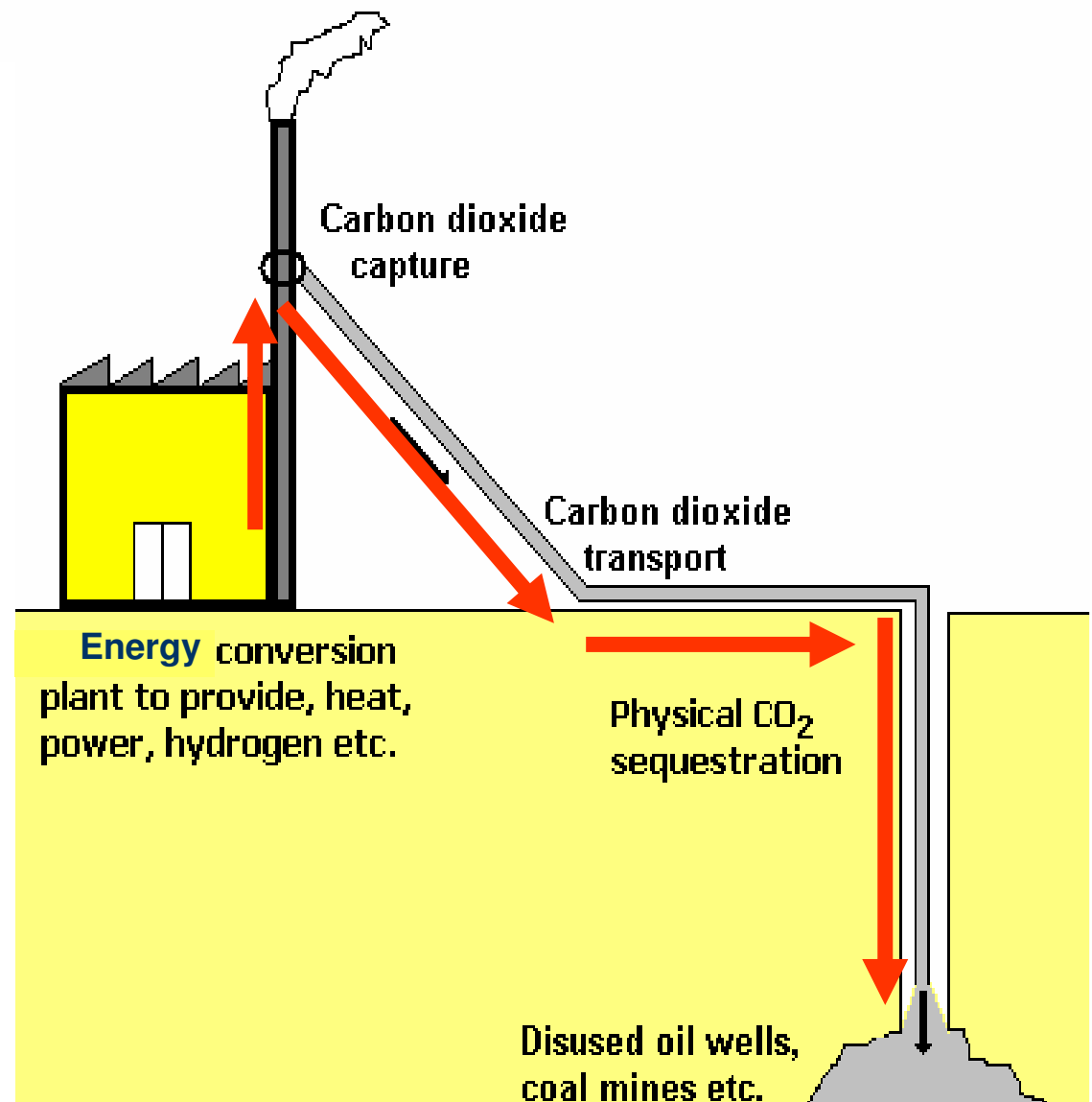
Is the “Energy in” less than the “Energy out”?



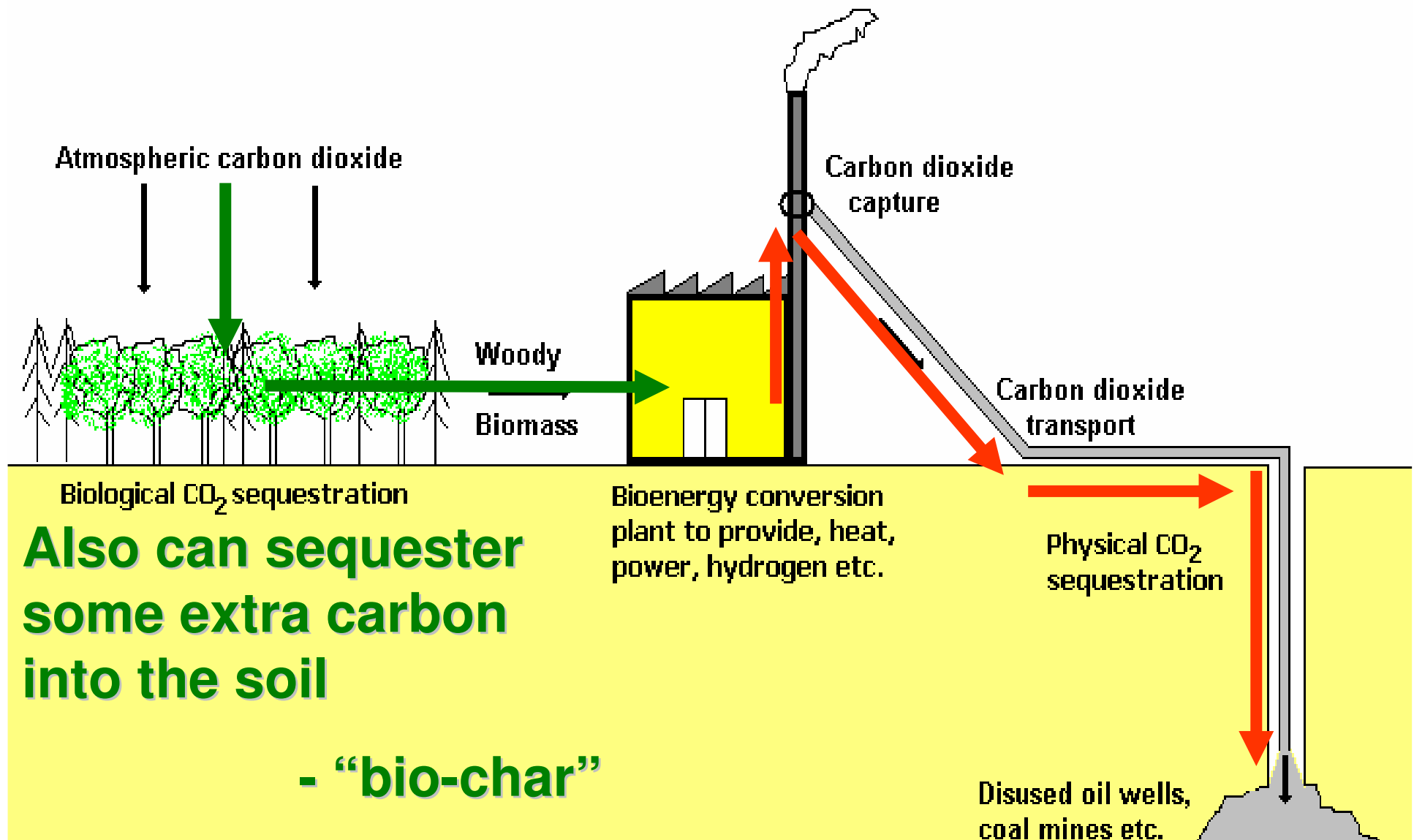
Carbon dioxide emissions.



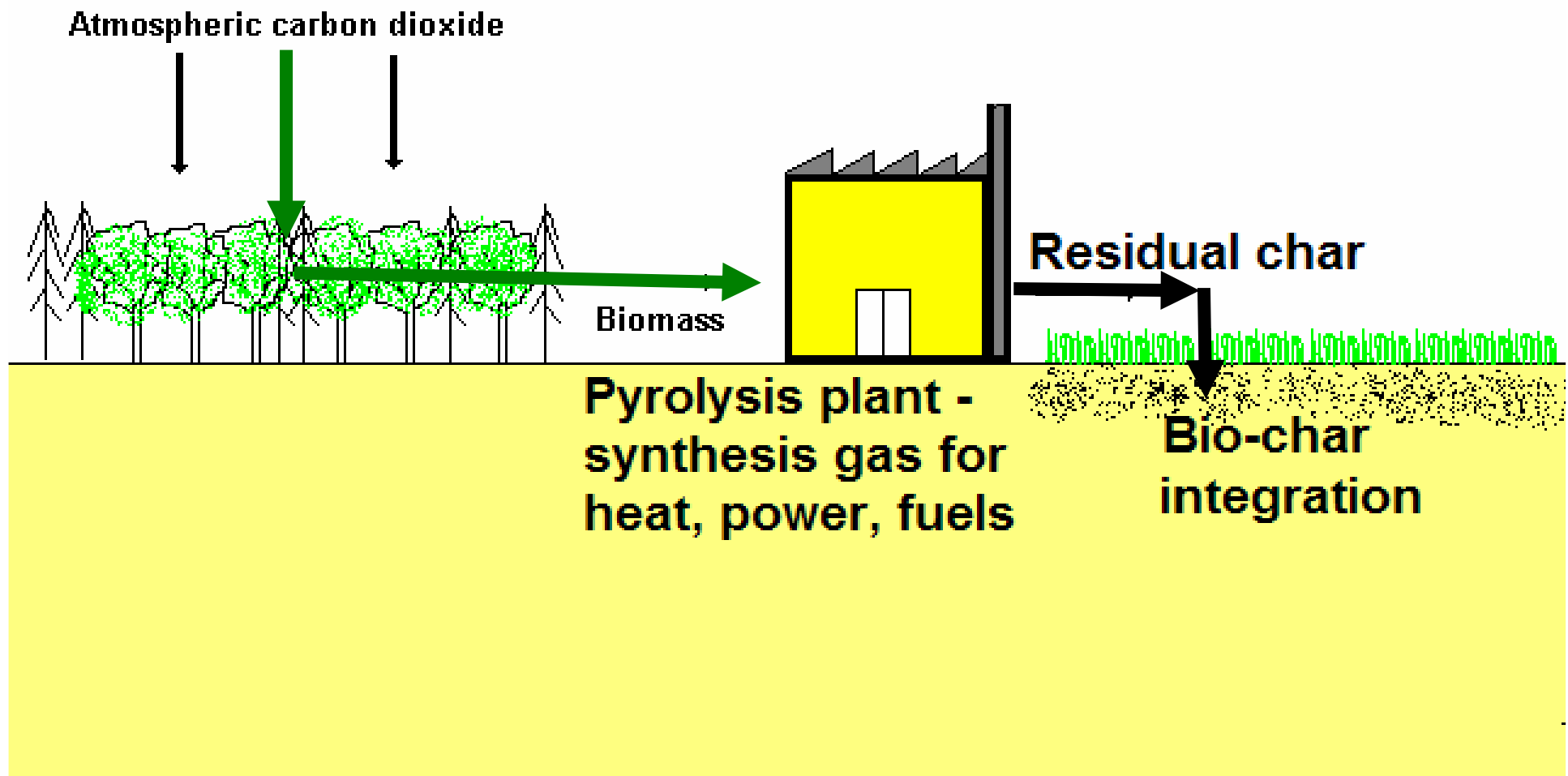
Carbon dioxide capture and storage.



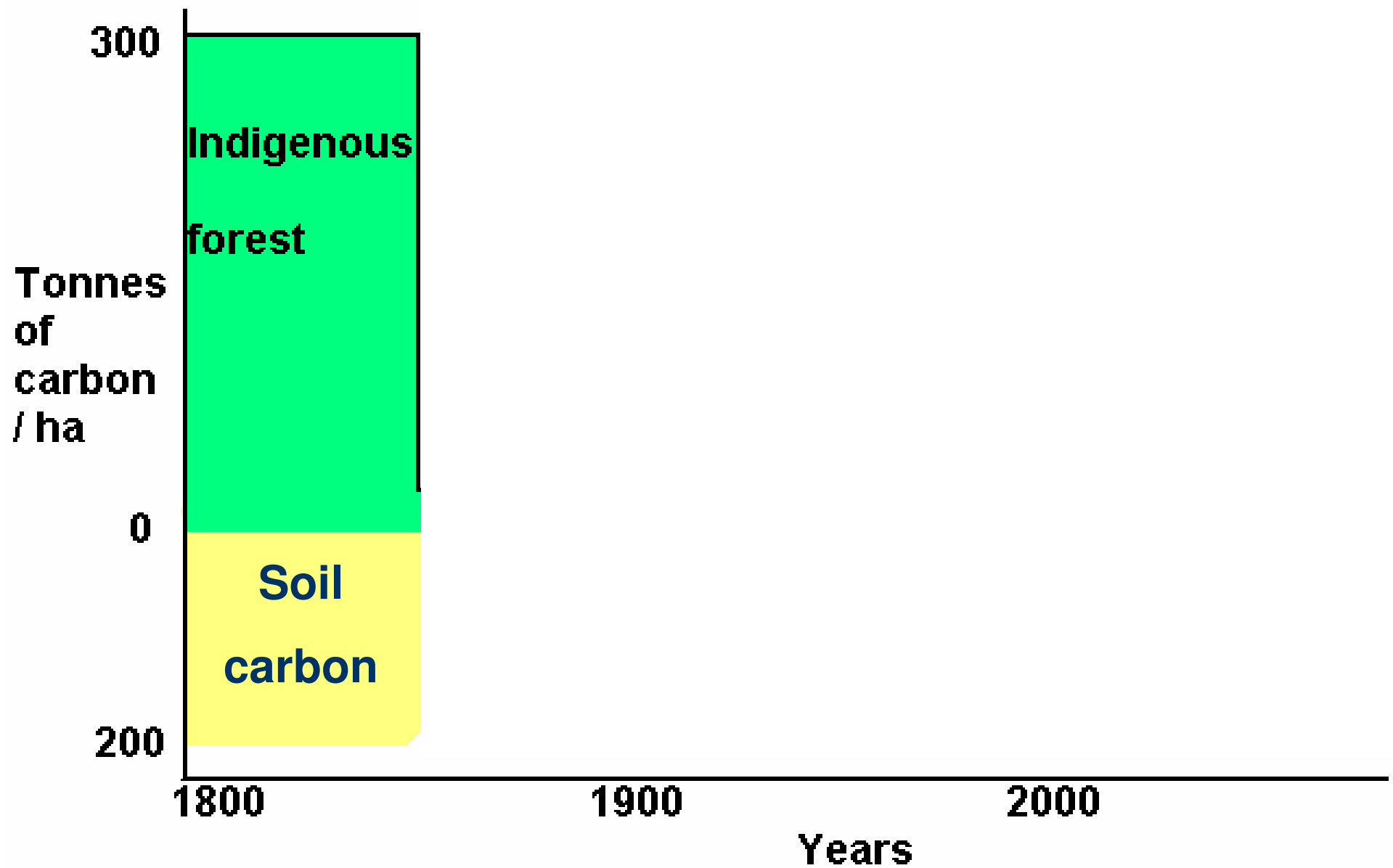
Carbon dioxide capture and storage linked with bioenergy.



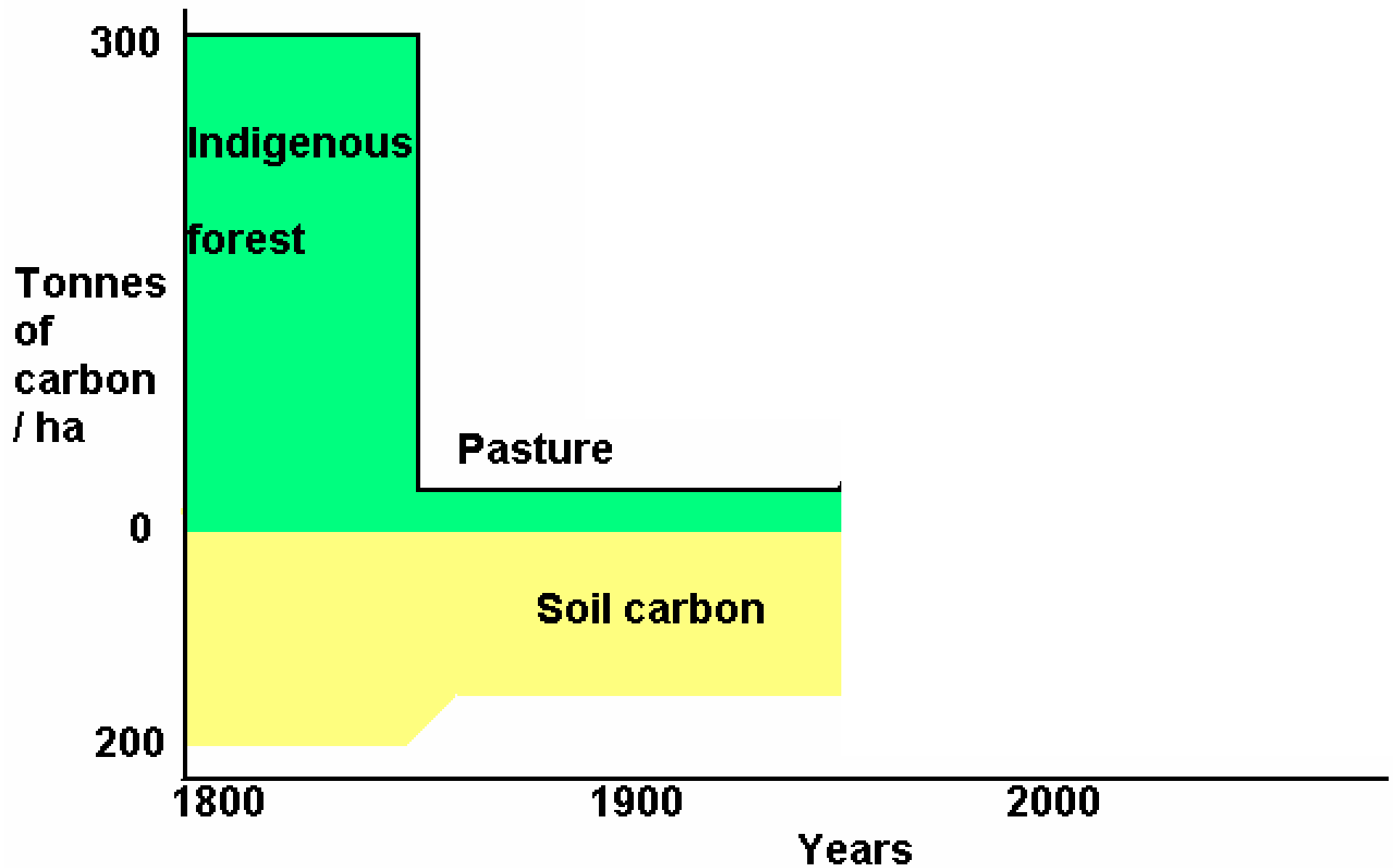
- **Pyrolysis of biomass gives CO + H₂**
- **This synthesis gas used for a range of products.**
- **Residual char is incorporated in the soil.**
- **Holds moisture + nutrients to improve plant growth.**



Forest carbon stocks



Deforest carbon emissions

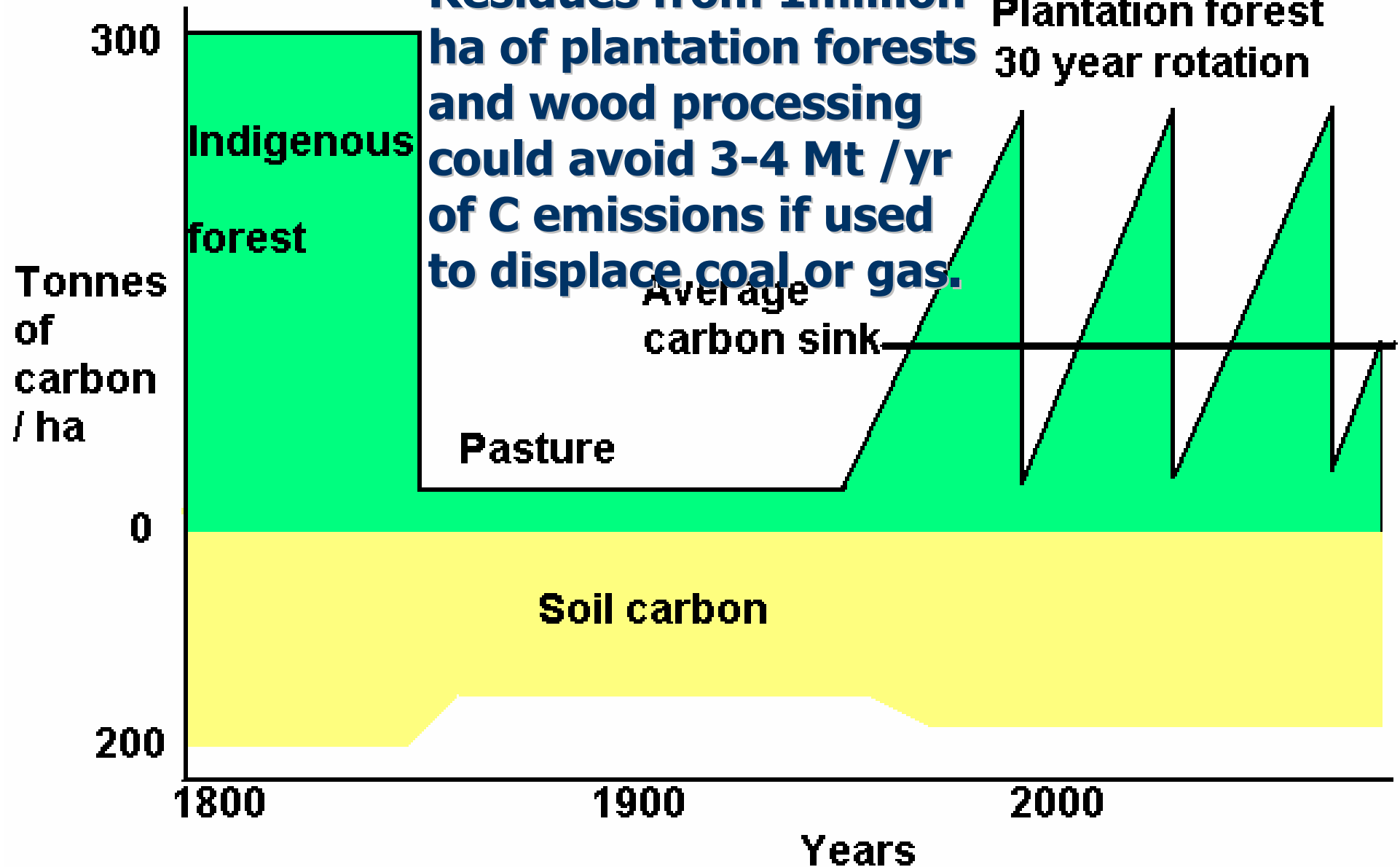


Forest carbon sinks

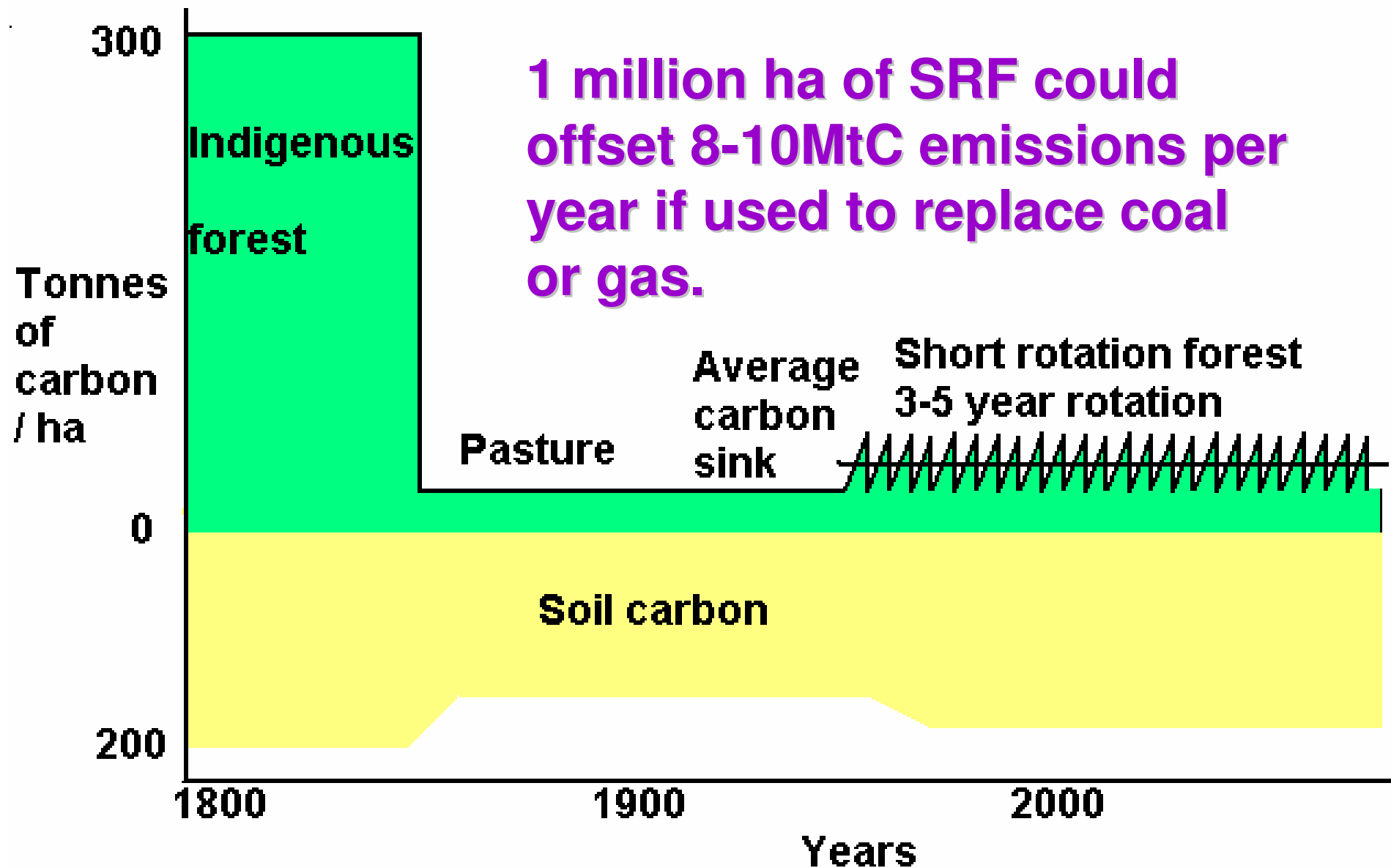
Carbon Offsets:

Residues from 1million ha of plantation forests and wood processing could avoid 3-4 Mt /yr of C emissions if used to displace coal or gas.

Plantation forest 30 year rotation



Forest carbon sinks – short rotation



In summary

Productive land is limited.

Availability for non-food crops will be determined by increased yield potential, reducing losses and wastes and lower inputs

Future yield increases are uncertain but possible.

Integration of energy crops with bio-char could also boost crop yields.

What chance for marine plant production?

