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Biofuel sustainability
Recent developments and ways forward

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Queen's Institute for Energy & Environmental Policy/

UBC Forest Products Biotechnology

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Today's talk

- Bioenergy and sustainability issues
- Certification of sustainability
- Biorefining and certification
- Summary

Bioenergy and sustainability issues

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Sciencexpress Report

Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change

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Most prior studies have found that substituting biofuels for gasoline will reduce greenhouse gasses because biofuels sequester carbon through the growth of the feedstock. These analyses have failed to count the carbon emissions that occur as farmers worldwide respond to higher prices and convert forest and grassland to new cropland to replace the grain (or cropland) diverted to biofuels. Using a worldwide agricultural model to estimate emissions from land use change, we found that corn-based ethanol, instead of producing a 20% savings, nearly doubles greenhouse emissions over 30 years and increases greenhouse gasses for 167 years. Biofuels from switchgrass, if grown on U.S. corn lands, increase emissions by 50%. This result raises concerns about large biofuel mandates and highlights the value of using waste products.

Most life-cycle studies have found that replacing gasoline with ethanol modestly reduces greenhouse gasses (GHGs) if made from corn and substantially if made from cellulose or sugarcane.(*1–8*). These studies compare emissions from the separate steps of growing or mining the feedstocks (such as corn or crude oil), refining them into fuel, and burning the fuel in the vehicle. In these stages alone, as shown in Table 1, corn and cellulosic ethanol emissions exceed or match those from fossil fuels, and therefore produce no greenhouse benefits. But because growing biofuel feedstocks removes carbon dioxide from the atmosphere, biofuels can in theory reduce GHGs relative to fossil fuels. Studies assign biofuels a credit for this sequestration effect, which we call the "carbon uptake" credit. It is typically large enough that overall GHG emissions from biofuels are lower than those from fossil fuels, which do not receive such a credit because they take their carbon from the ground.

For most biofuels, growing the feedstock requires land, so the credit represents the carbon benefit of devoting land to biofuels. Unfortunately, by excluding emissions from land use change, most previous accountings were one-sided because they counted the carbon benefits of using land for biofuels but not the carbon costs – the carbon storage and sequestration sacrificed by diverting land from its existing uses. Without biofuels, the extent of cropland reflects the demand for food and fiber. To produce biofuels, farmers can directly plow up more forest or grassland, which releases to the atmosphere much of the carbon previously stored in plants and soils through decomposition or fire. The loss of maturing forests and grasslands also forgoes ongoing carbon sequestration as plants grow each year, and this foregone sequestration is the equivalent of additional emissions. Alternatively, farmers can divert existing crops or croplands into biofuels, which causes similar emissions indirectly. The diversion triggers higher crop prices, and farmers around the world respond by clearing more forest and grassland to replace crops for feed and food. Studies have confirmed that higher soybean prices accelerate clearing of Brazilian rainforest. (*9*) Projected corn ethanol in 2016 would use 43% of the U.S. corn land harvested for grain in 2004 (*1*)—overwhelmingly for livestock (*10*)—requiring big land use changes to replace that grain.

Because existing land uses *already* provide carbon benefits in storage and sequestration (or, in the case of cropland, carbohydrates, proteins and fats), dedicating land to biofuels can potentially reduce greenhouse gasses only if doing so *increases* the carbon benefit of land. Proper accountings must reflect the net impact on the carbon benefit of land, not merely count the gross benefit of using land for biofuels. Technically, as shown in Table 1, to generate greenhouse benefits, the carbon generated on land to displace fossil fuels (the carbon uptake credit) must exceed the carbon storage and sequestration given up directly or indirectly by changing land uses (the emissions from land use change).

Many prior studies have acknowledged but failed to count emissions from land use change because they are difficult to quantify. (*1*) One prior quantification lacked formal agricultural modeling and other features of our analysis. (*11, 1*) To estimate land use changes, we used a worldwide model

Sciencexpress Report

Land Clearing and the Biofuel Carbon Debt

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Increasing energy use, climate change, and carbon dioxide (CO_2) emissions from fossil fuels make switching to low-carbon fuels a high priority. Biofuels are a potential low-carbon energy source, but whether biofuels offer carbon savings depends on how they are produced. Converting rainforests, peatlands, savannas, or grasslands to produce food-based biofuels in Brazil, Southeast Asia, and the United States creates a 'biofuel carbon debt' by releasing 17 to 420 times more CO_2 than the annual greenhouse gas (GHG) reductions these biofuels provide by displacing fossil fuels. In contrast, biofuels made from waste biomass or from biomass grown on abandoned agricultural lands planted with perennials incur little or no carbon debt and offer immediate and sustained GHG advantages.

Demand for alternatives to petroleum is increasing the production of biofuels from food crops such as corn, sugarcane, soybeans and palms. As a result, land in undisturbed ecosystems, especially in the Americas and Southeast Asia, is being converted to biofuel production and to crop production when agricultural land is diverted to biofuel production. Such land clearing may be further accelerated by lignocellulosic biofuels, which will add to the agricultural land base needed for biofuels unless biofuels are produced from crops grown on abandoned agricultural lands or from waste biomass.

Soils and plant biomass are the two largest biologically active stores of terrestrial carbon, together containing ~2.7 times more carbon than the atmosphere (*1*). Converting native habitats to cropland releases CO_2 due to burning or microbial decomposition of organic carbon stored in plant biomass and soils. After a rapid release from fire used to clear land or from decomposition of leaves and fine roots, there is a prolonged period of GHG release as coarse roots and branches decay and as wood products decay or burn (*2–4*).

We call the amount of CO_2 released during the first 50 years of this process the 'carbon debt' of land conversion. Over time, biofuels from converted land can repay this carbon debt if their production and combustion has net GHG emissions that are less than the life-cycle emissions of the fossil fuels they displace. Until the carbon debt is repaid, biofuels from converted lands have greater GHG impacts than the fossil fuels they displace. For crops with non-biofuel co-products (e.g., palm kernel oil and meal, soybean meal, or distillers' dry grains), we partition the carbon debt into a 'biofuel carbon debt' and a 'co-product carbon debt' based on the market values of the biofuel and its co-products (*5*).

Here we calculate how large biofuel carbon debts are, and how many years are required to repay them, for six different cases of native habitat conversion: Brazilian Amazon to soybean biodiesel, Brazilian Cerrado to soybean biodiesel, Brazilian Cerrado to sugarcane ethanol, Indonesian or Malaysian lowland tropical rainforest to palm biodiesel, Indonesian or Malaysian peatland tropical rainforest to palm biodiesel, and US Central grassland to corn ethanol (*5*) (table S1). These cases illustrate some of the greater current impacts of biofuels on habitat conversion. Indonesia and Malaysia account for 86% of global palm oil production (*6*). Accelerating demand for palm oil is contributing to the 1.5% annual rate of deforestation of tropical rainforests in these nations (*7*). An estimated 27% of concessions for new palm oil plantations are on peatland tropical rainforests, totaling 2.8 × 10^6 ha in Indonesia (*7*). Brazilian Cerrado is being converted to sugarcane and soybeans, and the Brazilian Amazon is being converted to soybeans (*8–10*). Grassland in the US, primarily rangeland or land currently retired in conservation programs, is being converted to corn production. Rising prices for corn, wheat, and soybeans could cause a substantial portion of the 1.5 × 10^7 ha of land currently in the US Conservation Reserve Program to be converted to cropland (*11*).

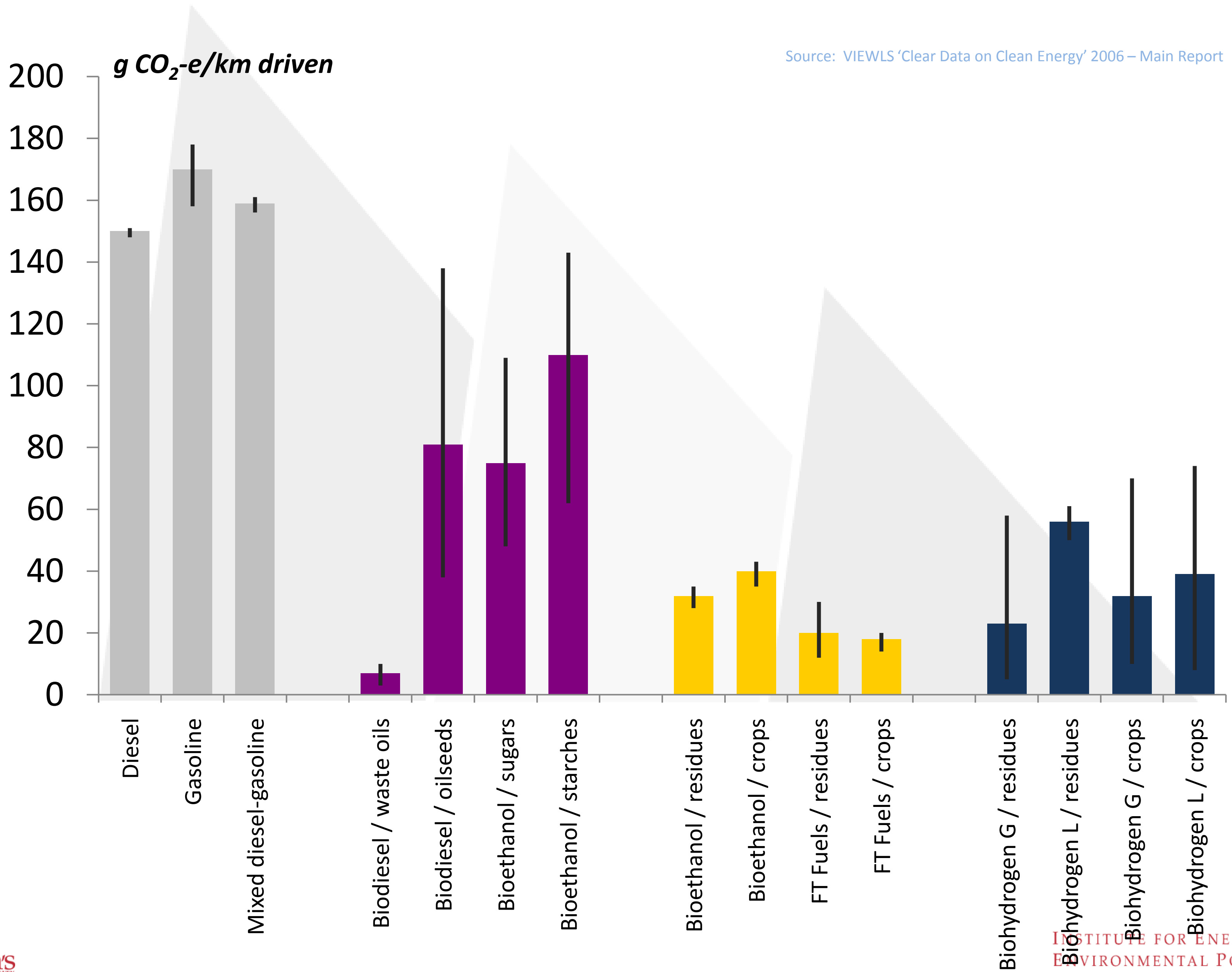
We estimated carbon debts by calculating the amount of CO_2 released from ecosystem biomass and soils. Our analyses account for the amount of plant carbon released as CO_2 through decomposition and combustion, the amount converted to charcoal (charcoal is not part of the carbon debt because it is recalcitrant to decomposition), and the amount incorporated into merchantable timber and other long-lived forestry products, which have a half-life of about 30 years (*3, 12*). Changes in carbon stores caused by land conversion and biofuel production, mainly from accelerated decomposition,

Indirect land use change (iLUC)

- Both papers address land use change – from ‘natural’ to managed
- Searchinger et al. – focus on transformation from food to fuel uses and downstream impacts, using US data
- Fargione et al. – focus on transformation from forest or grassland to cropland/plantation, using international data

- Both papers estimate ‘biofuel carbon debt’
- Common scenario – ‘grassland’ to corn

Biofuel emissions (without iLUC)



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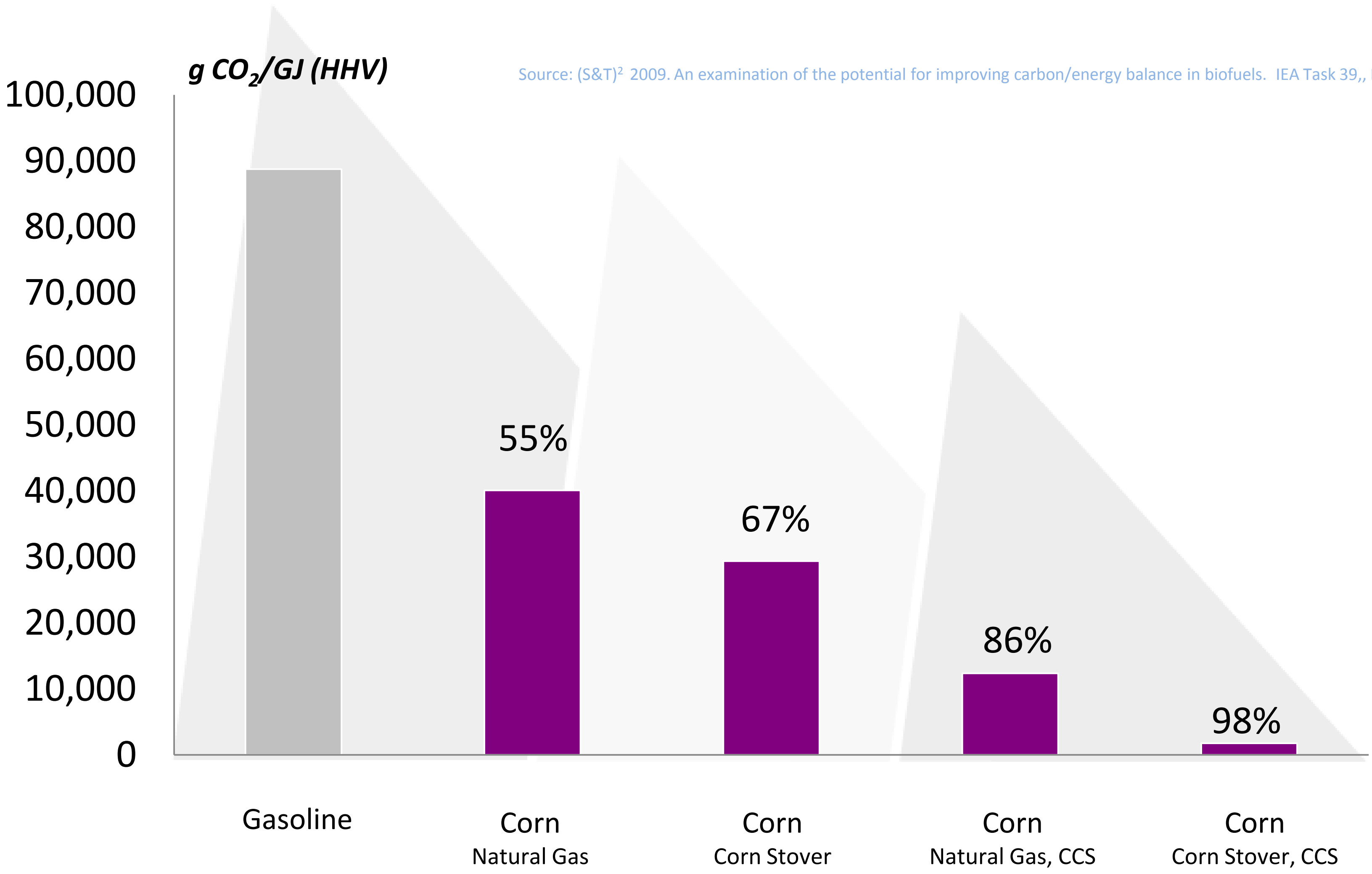
Potential emission scenarios (by 2015)



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Measuring sustainability

- Greenhouse gas balance
  g CO_2 km^{-1}, g CO_2-e km^{-1}, MJ km
- Energy balance (MJ in vs. MJ out)
- All based on lifecycle analysis (ISO Standard)
- 'Well-to-wheels' analysis:
  - Production of biomass
  - Transport of biomass
  - Conversion to transport fuel
  - Distribution of transport fuel
  - Use of transport fuel
- Other key issues: water consumption, biodiversity impacts
- Also social and cultural sustainability – 'creative economy'

Certification of sustainability

What is certification?

- An initiative that encourages landowners and/or industry to implement sustainable practices
- Designed to give consumers assurance that products come from sustainable processes and/or management
- Criteria for sustainability are measured using specific indicators

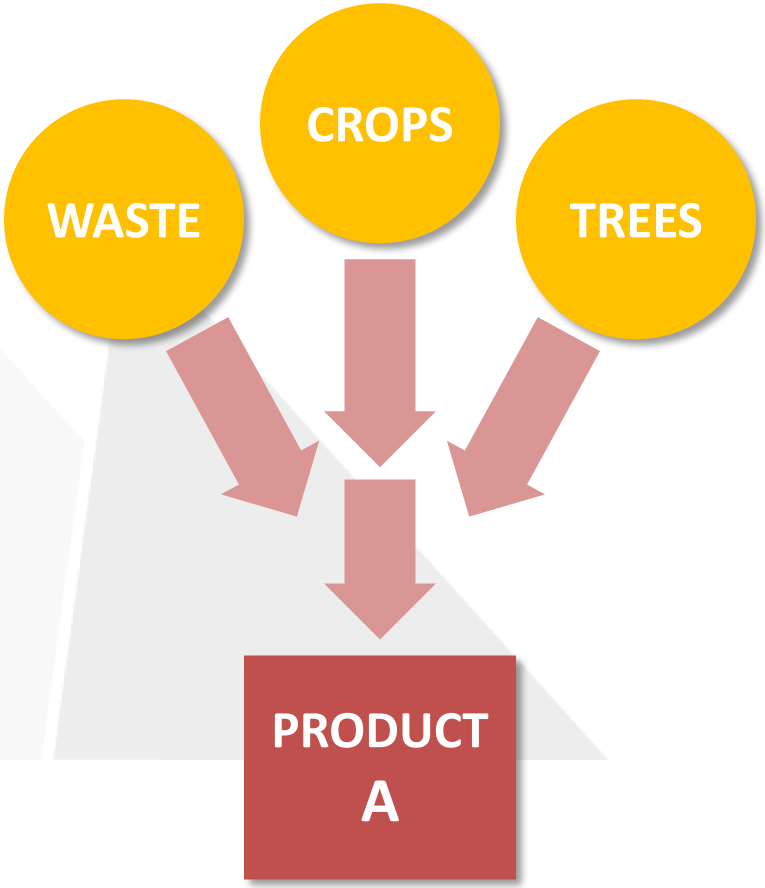
Certification criteria

1. Greenhouse gas balance & carbon sinks
2. Competition with food / other indirect land use change
3. Biodiversity
4. Local environmental effects
5. Local economic effects
6. Social well-being of employees
7. Indigenous peoples’ rights

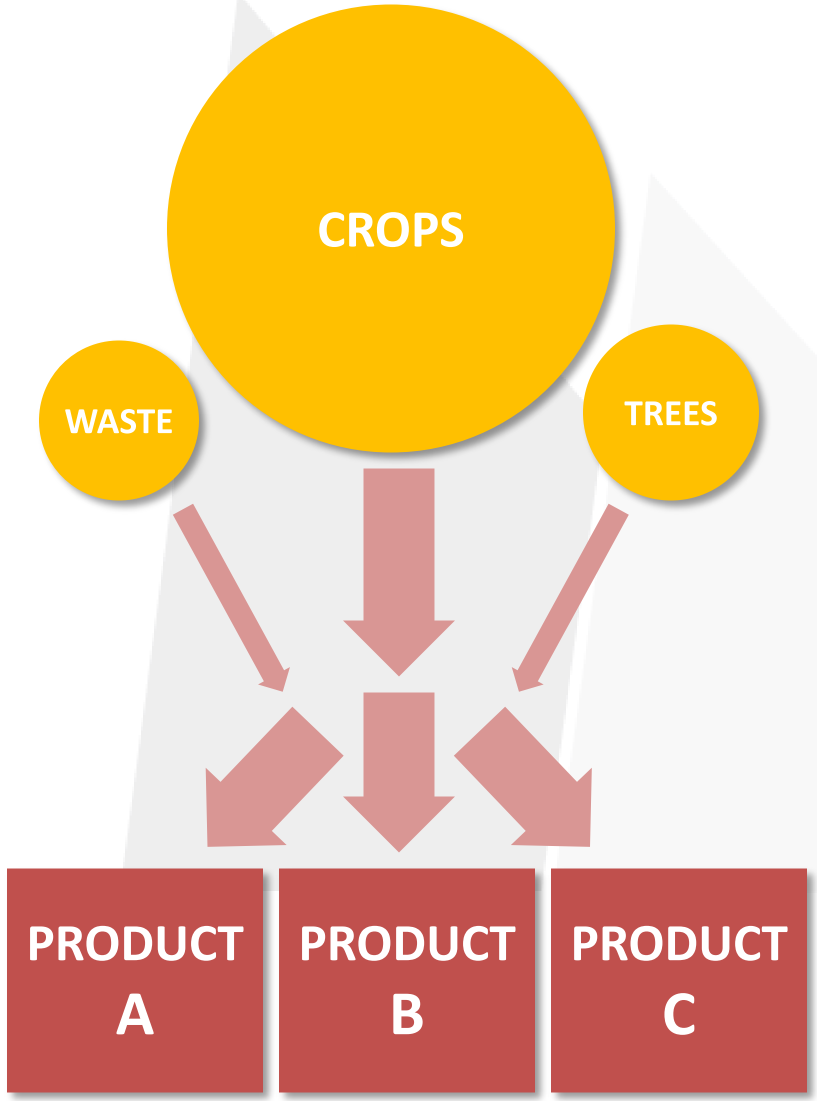
Sources: BTG 2008, Bronckers Verberne et al. 2007;
http://ec.europa.eu/energy/renewables/bioenergy/doc/sustainability_criteria_and_certification_systems.pdf

Two approaches

1. Chain-of-custody approach:
   - Use broad criteria, performance measures and specific indicators to monitor performance over time
   - Works well when a number of different pathways could lead to the same product, or when multiple feedstocks are used for one basic product category



Two approaches

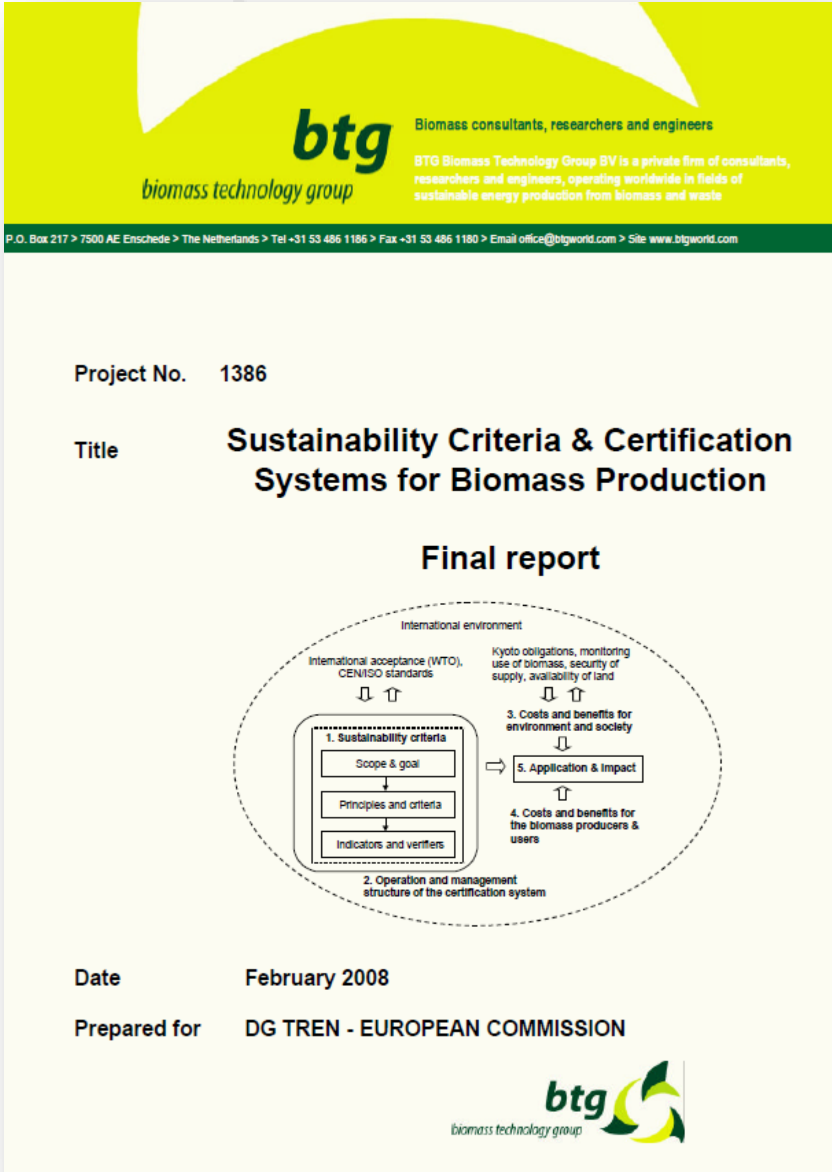


2. Management approach:
   - Generic guidelines and standards (ISO 14001)
   - Feedstock specific guidelines (i.e. Forestry specific guidelines such as SFI, CSA)
   - Works well when one dominant feedstock is used for multiple products

Certification schemes

- Biomass energy crops
  - Roundtable for Sustainable Palm Oil (RSPO)
    - Developed a set of criteria and indicators, certification system
- Power sector
  - Developed certification standards for internal use (i.e. Essent Green Gold Label)
  - Green electricity labels are usually national level
- Forest-based systems
  - Forest Stewardship Council
  - Programme for the Endorsement of Forest Certification Schemes
  - Others
  - Note: most forest-based systems are guided by International Standards Organisation (ISO) guidelines
- Clean Development Mechanism
  - Promotes sustainable development in host country

EC – Background report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Project No. 1386

Title **Sustainability Criteria & Certification Systems for Biomass Production**

Final report

Date February 2008

Prepared for DG TREN - EUROPEAN COMMISSION

btg
biomass technology group

- February 2008
- Summary of all sustainability criteria, certification systems for biomass production
- Prepared for DG-TREN (responsible for the Bioenergy Directive)

Source: http://ec.europa.eu/energy/renewables/bioenergy/doc/sustainability_criteria_and_certification_systems.pdf

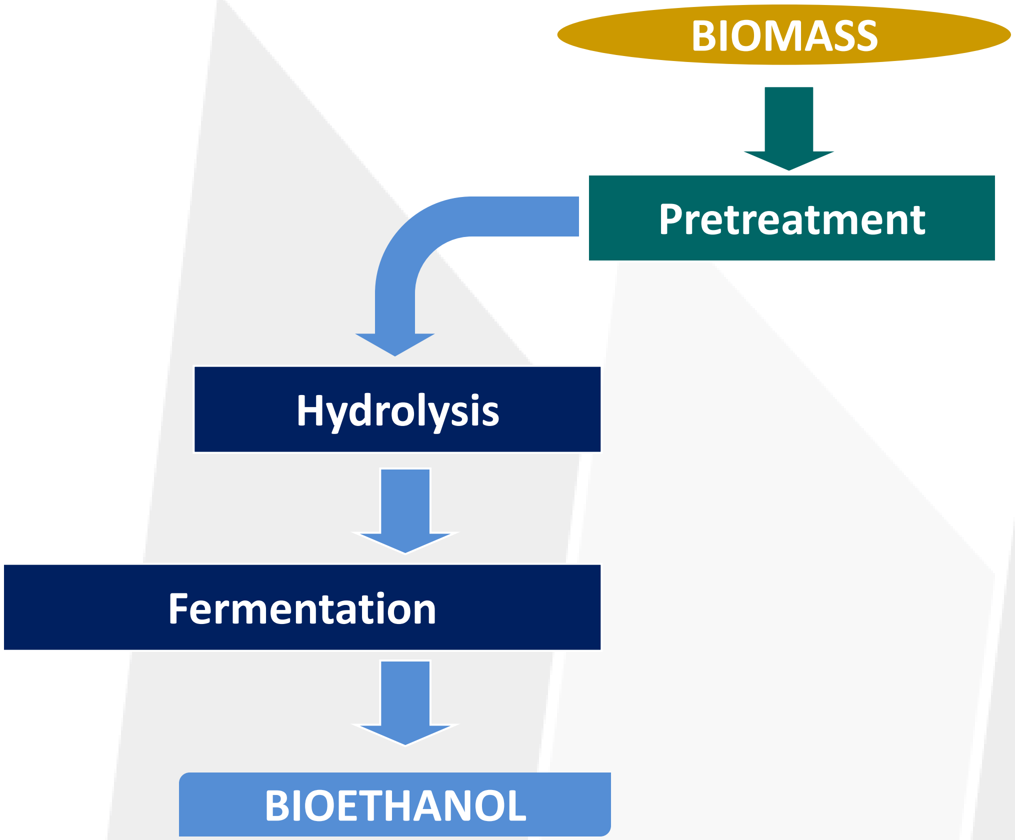
EC - Current Status

- **17 Dec. 2008**: EU Parliament voted in favour of a directive on the promotion of the use of energy from renewable sources (includes criteria for sustainability)

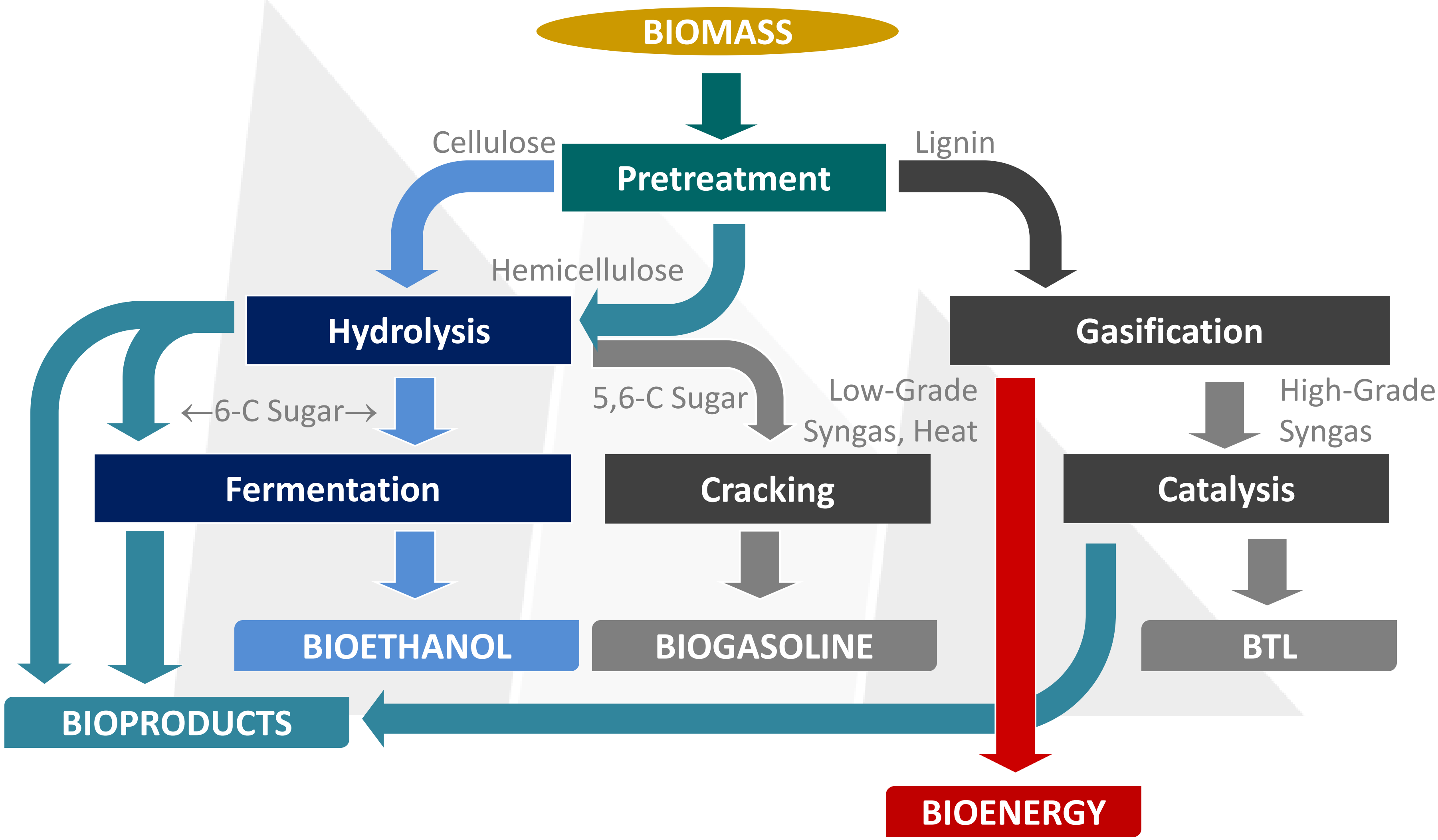
- **31 March 2010**: Deadline for EU states to present National Action Plans (NAPs) on renewables

Biorefining and certification

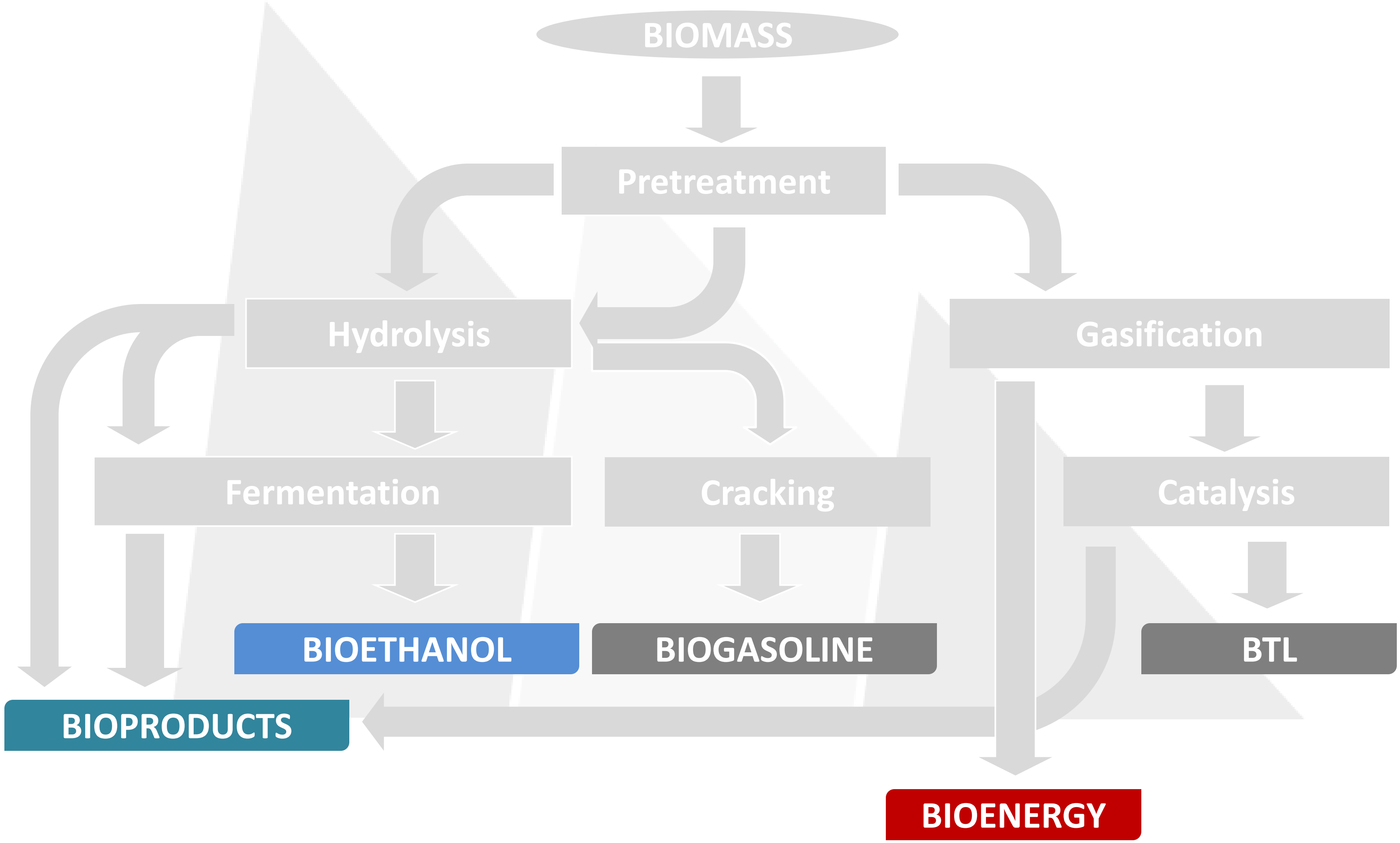
Biorefining



Biorefining



Biorefining



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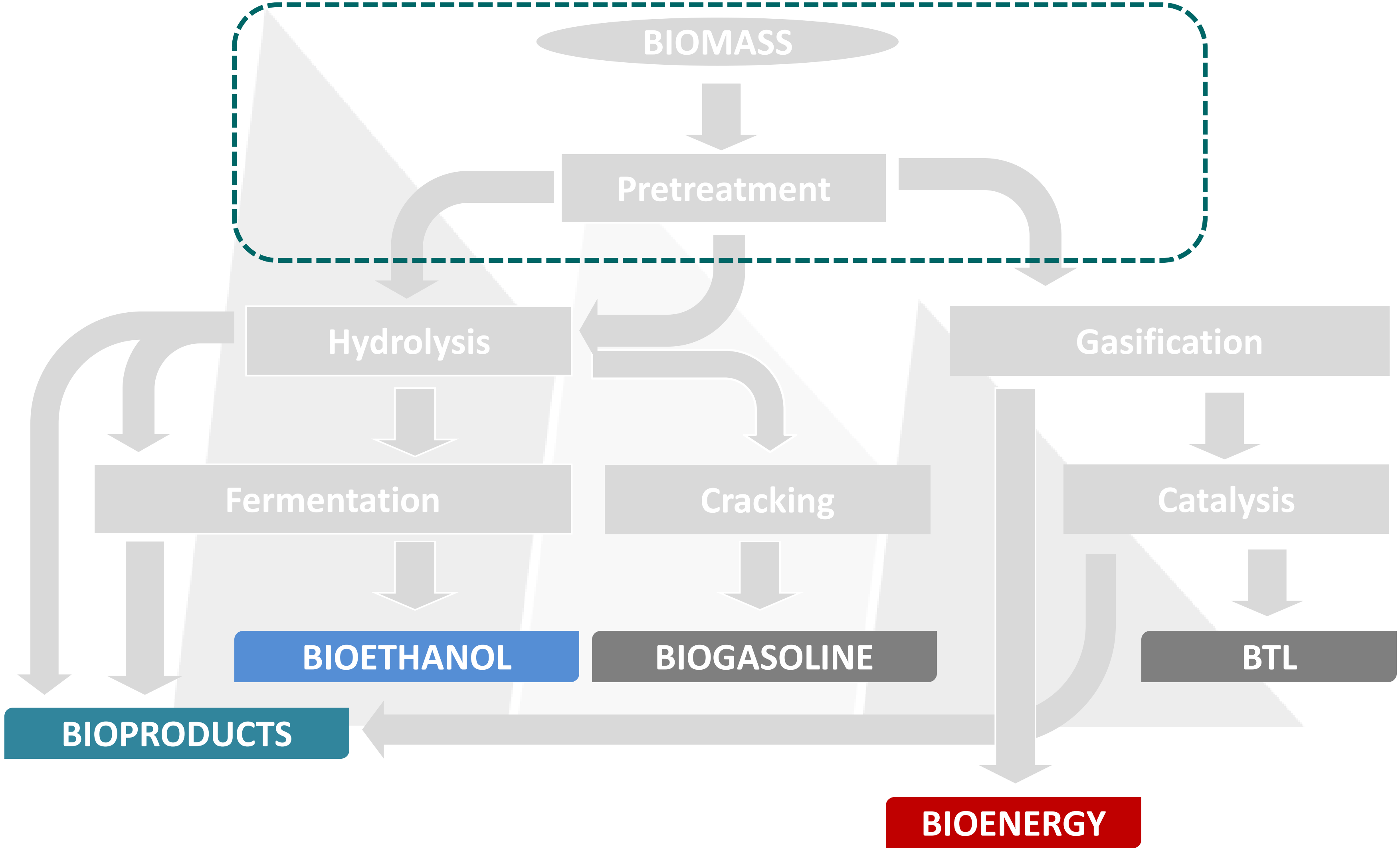
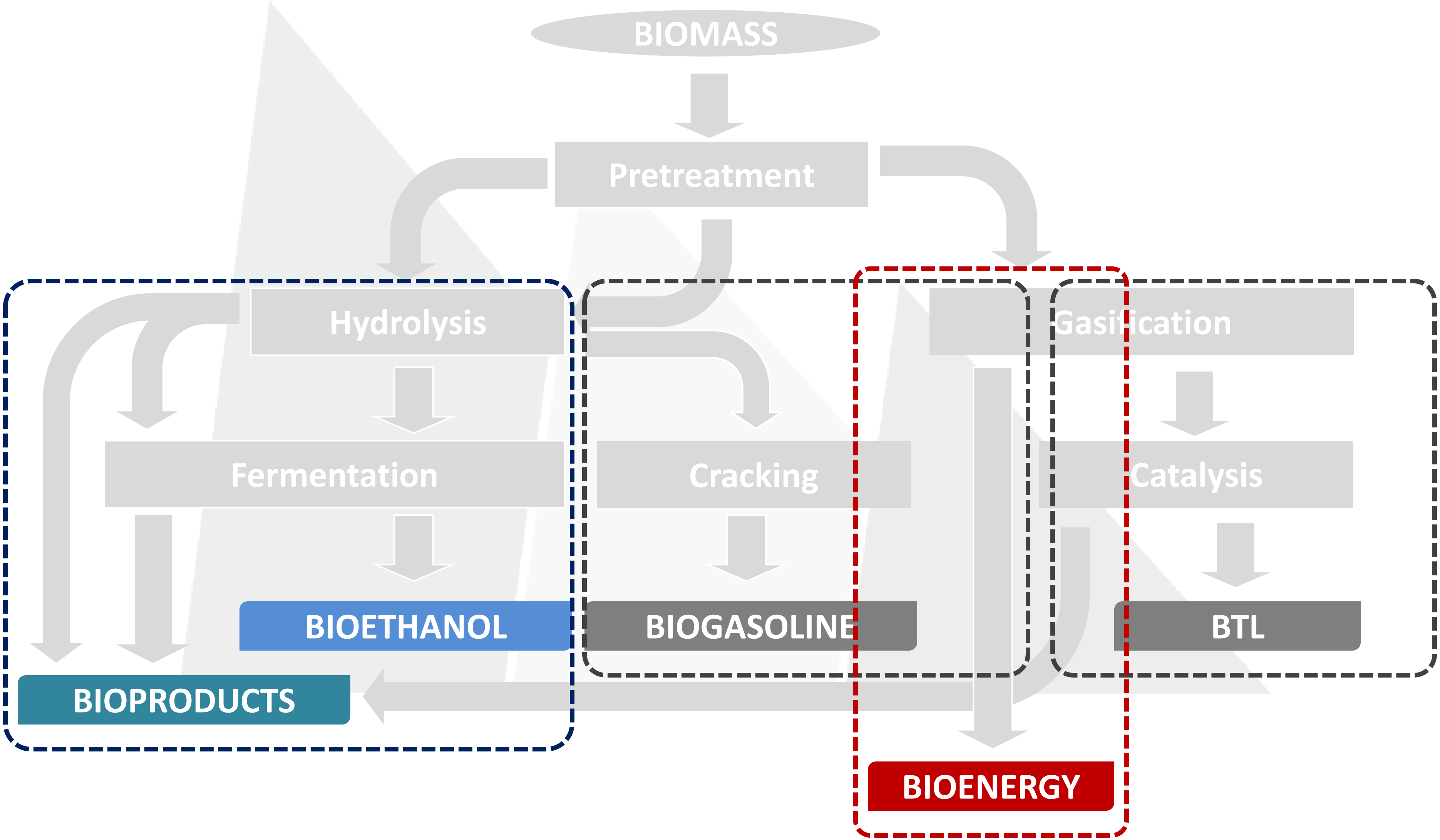
Management certification



Chain of custody certification



Conclusions

- Sustainability issues around biofuels has been focused on carbon balance – but sustainability actually means much more than just CO_2 reductions
- Even on the issue of CO_2-equivalent emissions, there is lots of flexibility; the goalposts continue to move
- EU experiences:
  - Considerable demand for sustainability criteria – an ongoing debate
  - Individual country efforts have helped shape this debate
  - Highlights the need for accepted certification schemes
- Biorefining requirements
  - Multiple product potential – not a simple certification fix
  - Management certification could be applied to feedstock production – focus would likely be environmental
  - Chain of custody certification applied to various product pathways – focus would likely be social and economic

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