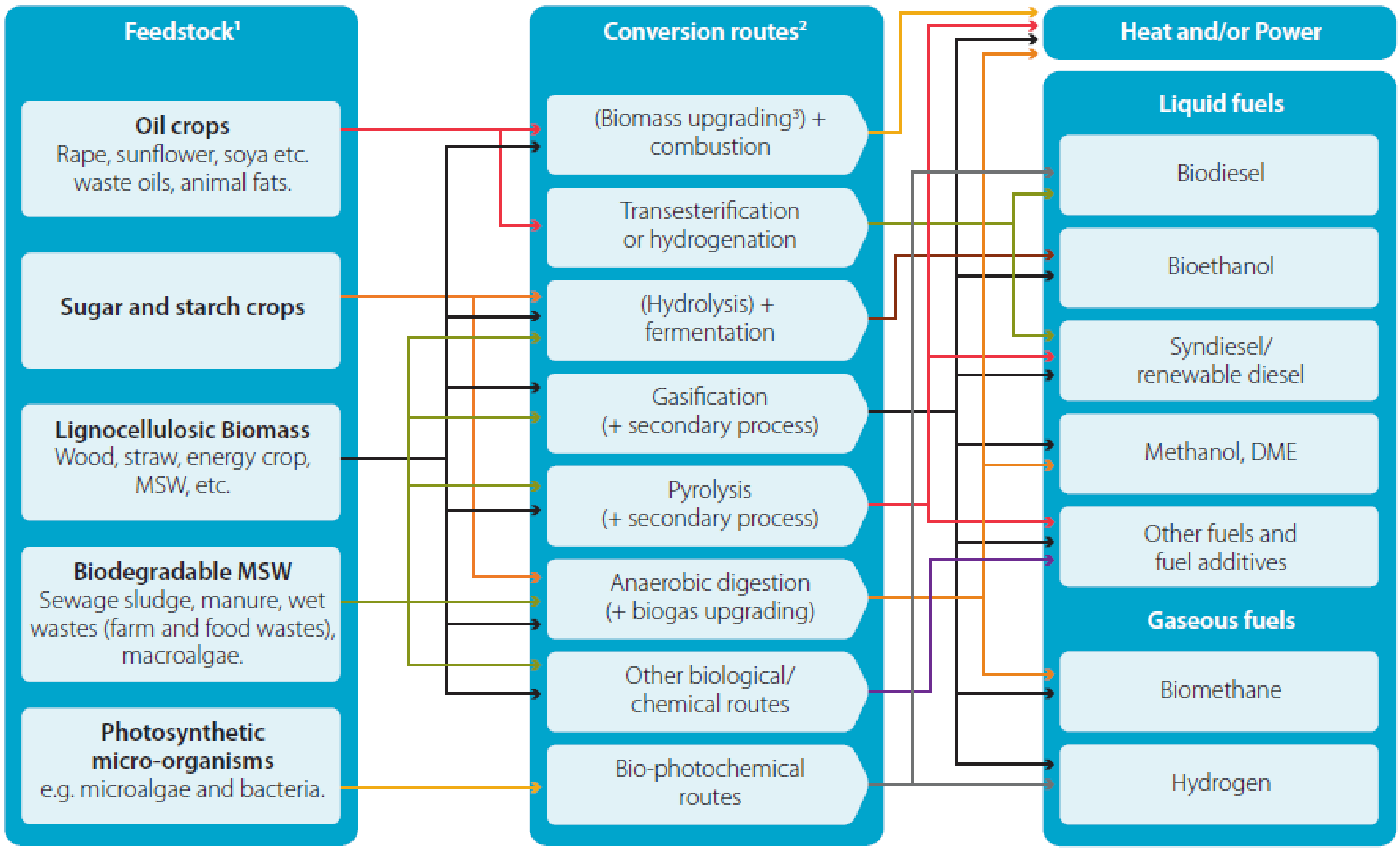
# Bioenergy review

**Dr Ute Collier**
**Committee on Climate Change**
BIEE presentation 31 January 2012

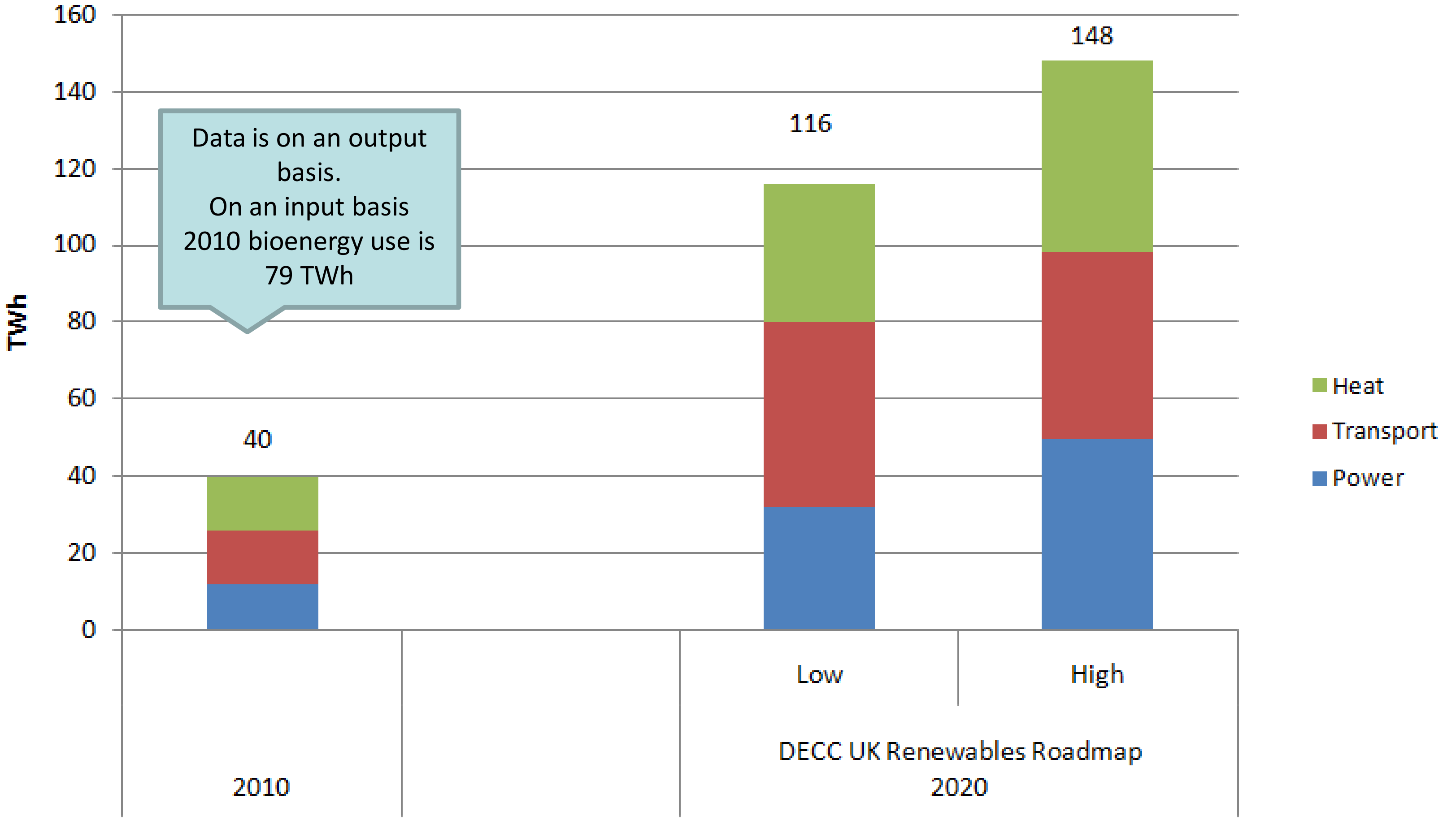

# Contents

# What is bioenergy?




Source: Bauen et al, 2009

# Current UK bioenergy use is small, but a large increase is expected to 2020



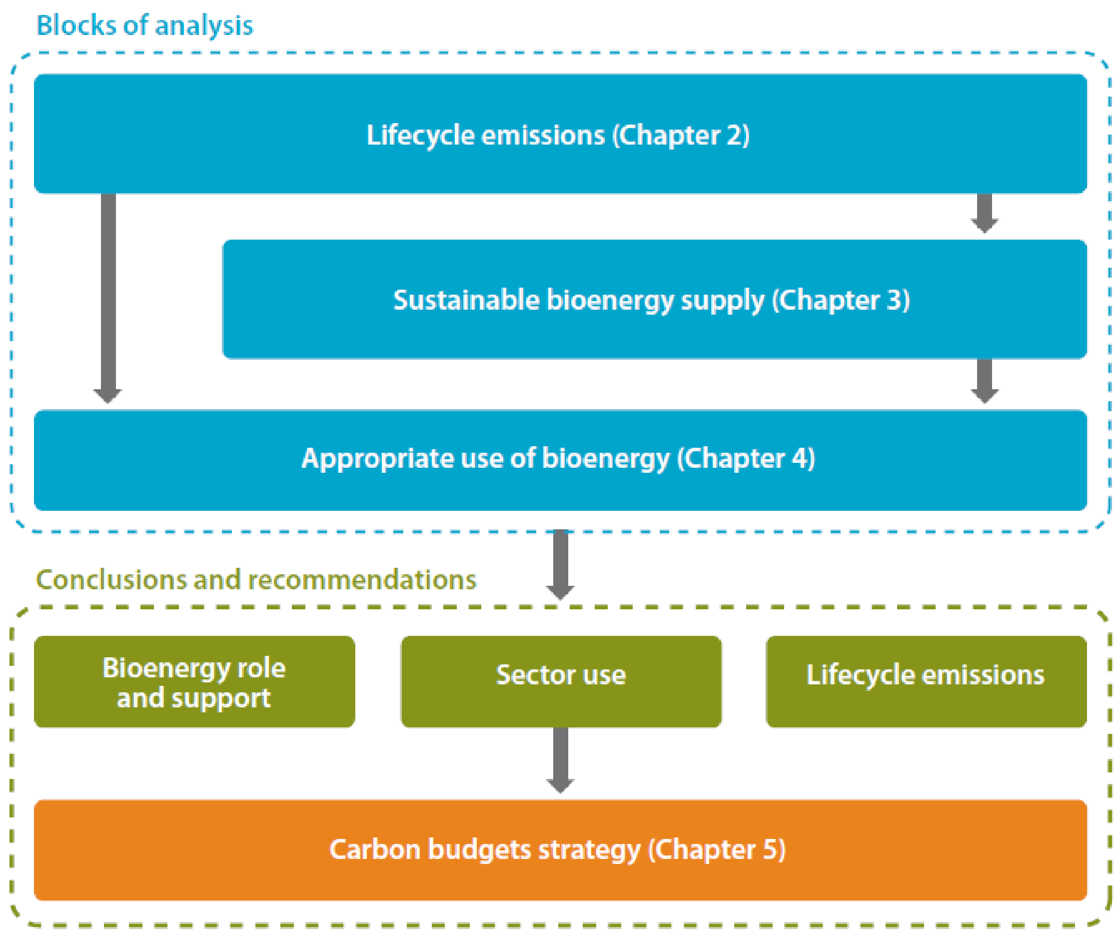
# Aims of the review and approach

**Aims:**

Assessment of the potential role for bioenergy in meeting carbon budgets given:

- lifecycle emissions and other sustainability concerns
- alternative uses for bioenergy feedstocks (e.g. wood in construction)

**Approach:**



# Contents

# Counting the carbon in bioenergy

‘Zero’ rated in carbon budgets

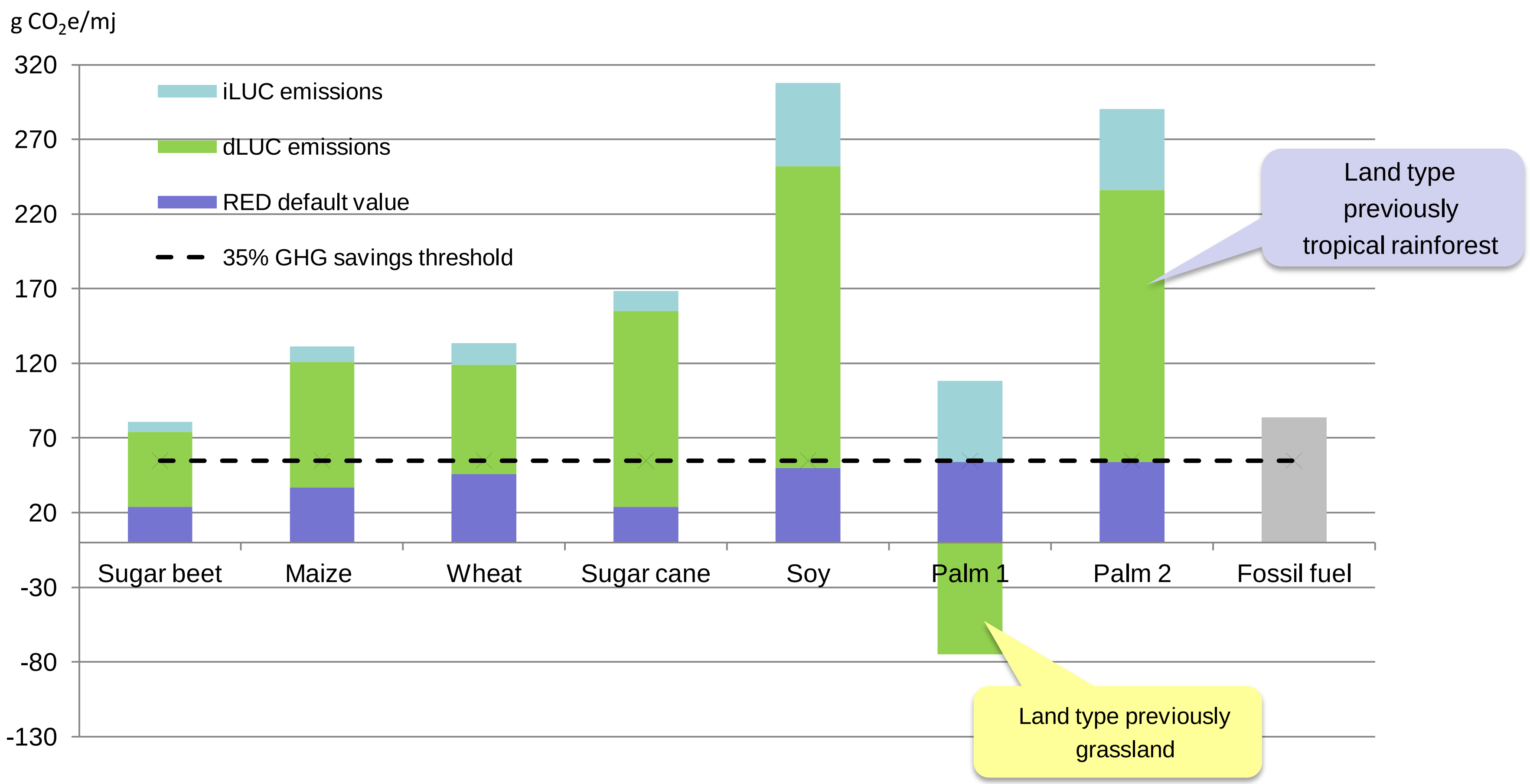
Bioenergy crops absorb carbon from the atmosphere as they grow

And release the carbon when combusted

Additional emissions due to cultivation, production, transport, land-use change (direct and indirect)

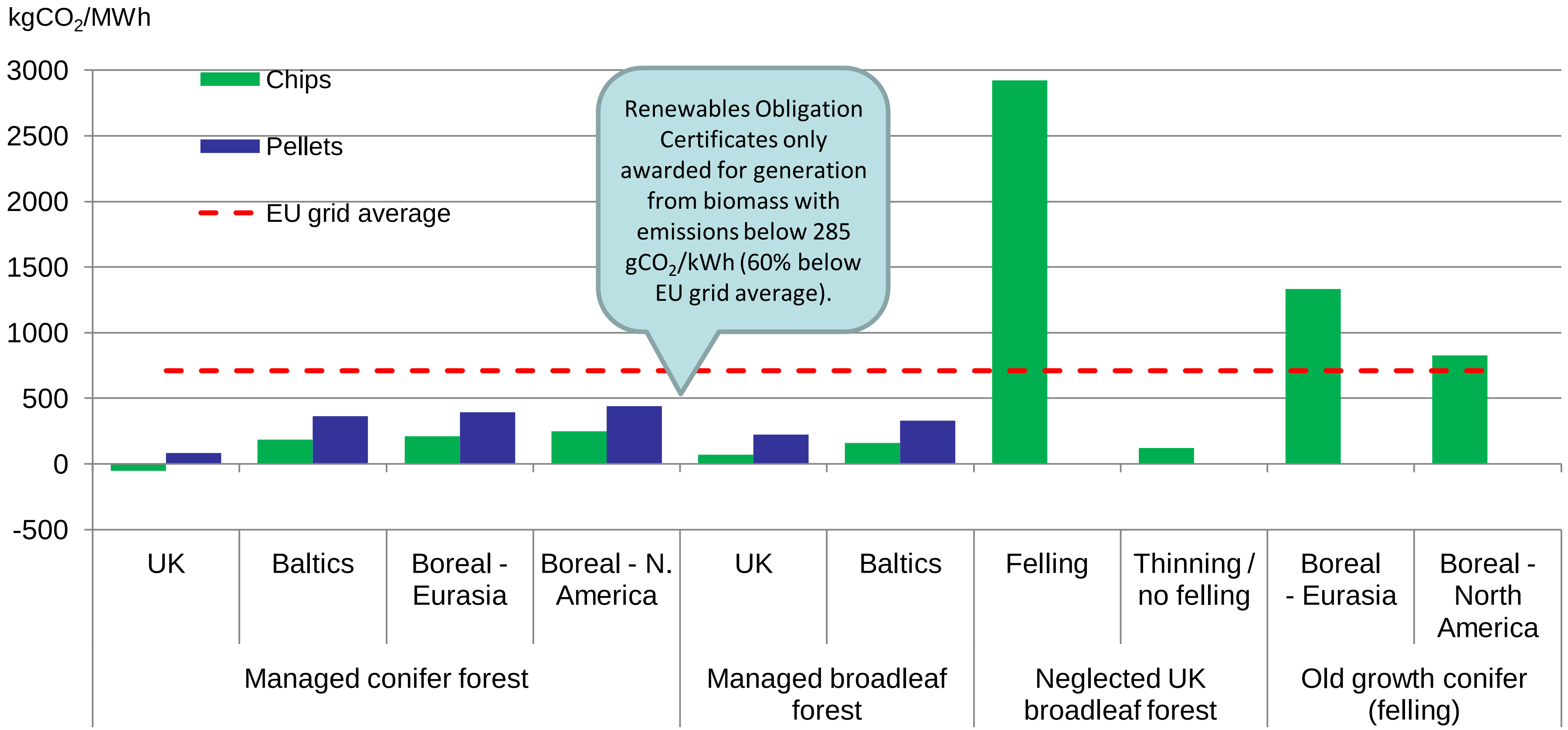
Incomplete carbon accounting under international rules – partially addressed through EU and UK bioenergy sustainability criteria

# Liquid biofuels – some illustrative examples




Source: EU-RED, IFPRI (2011), M. Lange (2011)
Note: DLUC assumes grassland converted to grow sugar beet, maize and wheat; scrubland to grown sugarcane and soy.

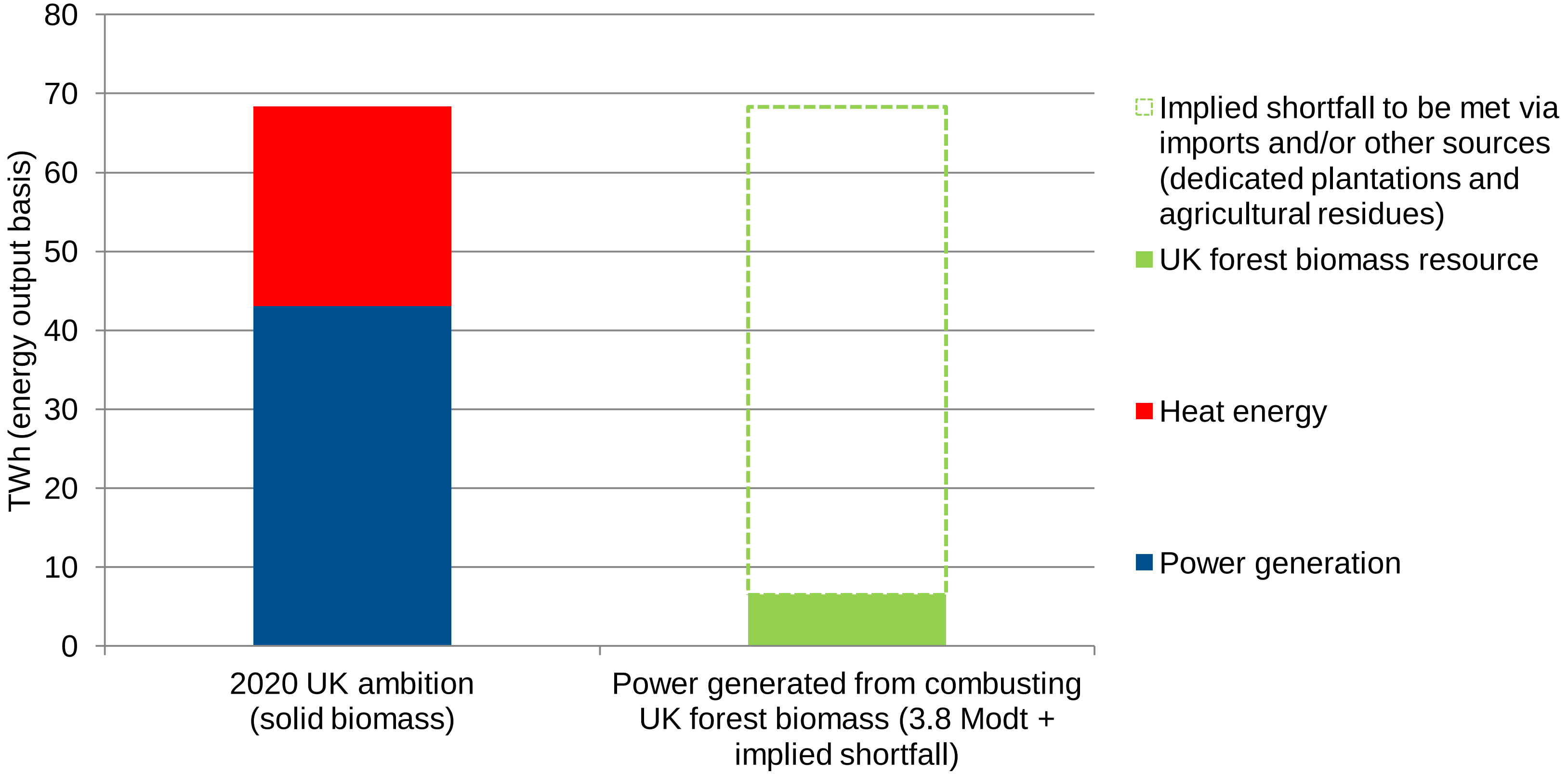
# Solid (forest) biomass




Source: Environment Agency BEAT2

Current sustainability framework under RO / RHI limits risks of direct deforestation, but not indirect (i.e. displacing current wood demand to unsustainable supply sources)

# Solid biomass feedstocks - ambition in power and heat generation will have to be met largely through imports




Power and heat sectors may require ~30 million tonnes of solid biomass in 2020 (UK Renewable Roadmap, 2011) = total amount currently used by all wood consuming sectors (primarily construction, wood panels, pulp & paper).

# Conclusions – is bioenergy low-carbon?

Committee on Climate Change

- **Liquid biofuels**: risk that near-term targets result only in small or even negative emission savings:
  - ➡ Should include ILUC & may need to adjust ambition if sustainable supply not forthcoming
- **Solid biomass**: Emissions saving under current framework is low, particularly given risk of indirect impact; small saving relative to CCGT:
  - ➡ Increase required emissions saving (tighten standard for biomass from 285 $gCO_2$ / kWh to 200 $gCO_2$ / kWh)
  - ➡ Consider broader sustainability standard for all wood in UK / EU

# Contents


1. Context:
2. Key messages of today's report
3. Is bioenergy low-carbon?
4. Sustainable bioenergy supply
5. Appropriate use of scarce bioenergy
6. Key conclusions

# A rising and increasingly wealthy global population will lead to a 70% increase in food demand by 2050

Committee on Climate Change

Global **population** to reach almost 9 billion by 2050

**Incomes** grow by 2.7% per year between 2030 and 2050

Average daily **consumption** rises from c.2820 to over 3130 kcal per day between now and 2050

**Meat consumption** Increases from 37 kg to 52kg/person/yr

The UN FAO forecast a **small increase (5%) in the amount of arable land** required for food production on the basis that increased demand can largely be met through **agricultural productivity improvement**.

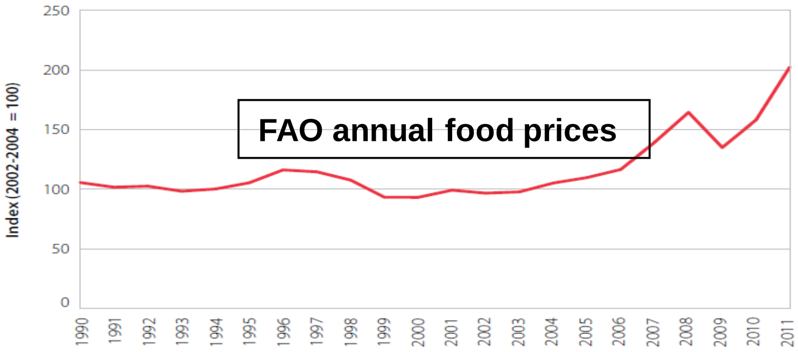
Productivity improvement at historic rate - 2% per year for cereals - would free-up additional land but this is unlikely going forward

**Sustainable intensification** and **innovative farming practices** will be required to make more effective use of land and water resources

# 4 CCC scenarios illustrating a broad range of alternative futures, taking into account sustainability constraints

Committee on Climate Change

**Food security:** Even now at a relatively low level of bioenergy use, there is some evidence that biofuels is one of many significant factors driving food price spikes in recent years




**Biodiversity:** Abandoned agricultural land often has high biodiversity value

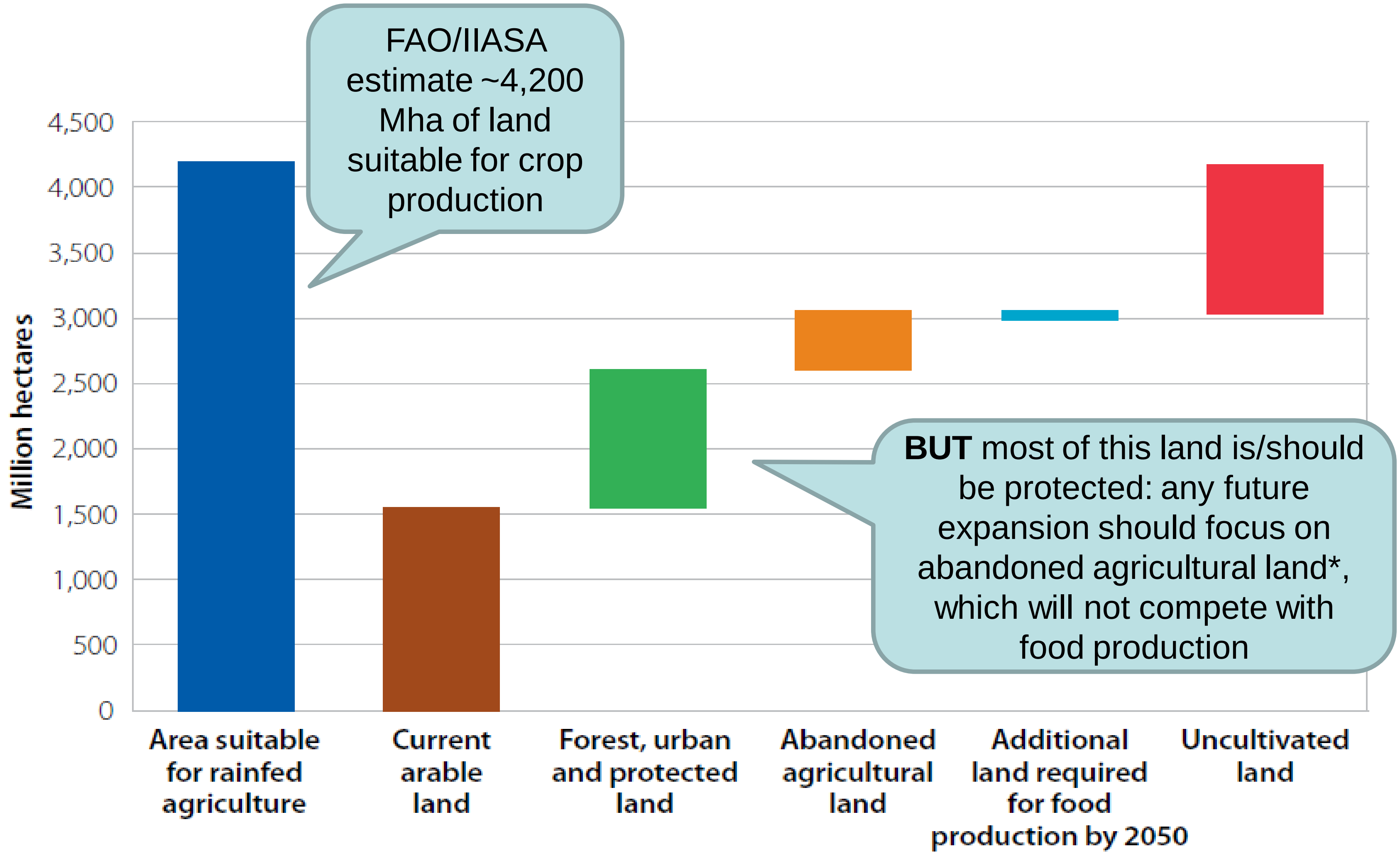
**Water stress:** may constrain ability to grow energy crops / or development may exacerbate water shortages

**Ethical and social issues:** "abandoned" land rarely unused and serves a variety of purposes, e.g. subsistence farming and common grazing

**N.B.: Uncertainty is inherent in bioenergy supply estimates:**

- Land use data
- Impacts of future climate change
- Complexity of factors affecting global land use and agricultural production

# Limited scope for bioenergy on land required for food: we identify abandoned agricultural land* as potentially suitable for bioenergy crops




* Abandoned agricultural land is land previously used for cultivating crops but is no longer in production due to a variety of reasons, as estimated by Campbell et al., (2008); Cai et al., (2011).

# Our core scenarios focus on the use of abandoned agricultural land – we also include two further land conversion scenarios, which are highly uncertain

Committee on Climate Change

| | | | |
|---|---|---|---|
| **Constrained land use (CLU)** | 100 Mha | Stringent nature conservation and water constraints | Low yield (5t/ha) |
| **Extended land use (ELU)** | 400 Mha | Relax environmental constraints on abandoned agricultural land | Low yield (5t/ha) |
| **Further land conversion (FLC) (Agricultural land)** | 700 Mha | Implies productivity improvement OR diet shift | Yield 5t/ha - 15t/ha |
| **Further land conversion (FLC) (Natural habitats)** | 700 Mha | Implies conversion of unprotected woodland/grassland | Yield 5t/ha - 15t/ha |

We assume in the longer term dedicated energy crop feedstocks are a mix of fast growing trees and grasses, as these crops are potentially more suitable to land of low productivity, have low lifecycle emissions and can be converted for use across the range of sectors

# There is a wide range of estimate, and our scenarios are at the low end of the range from the literature

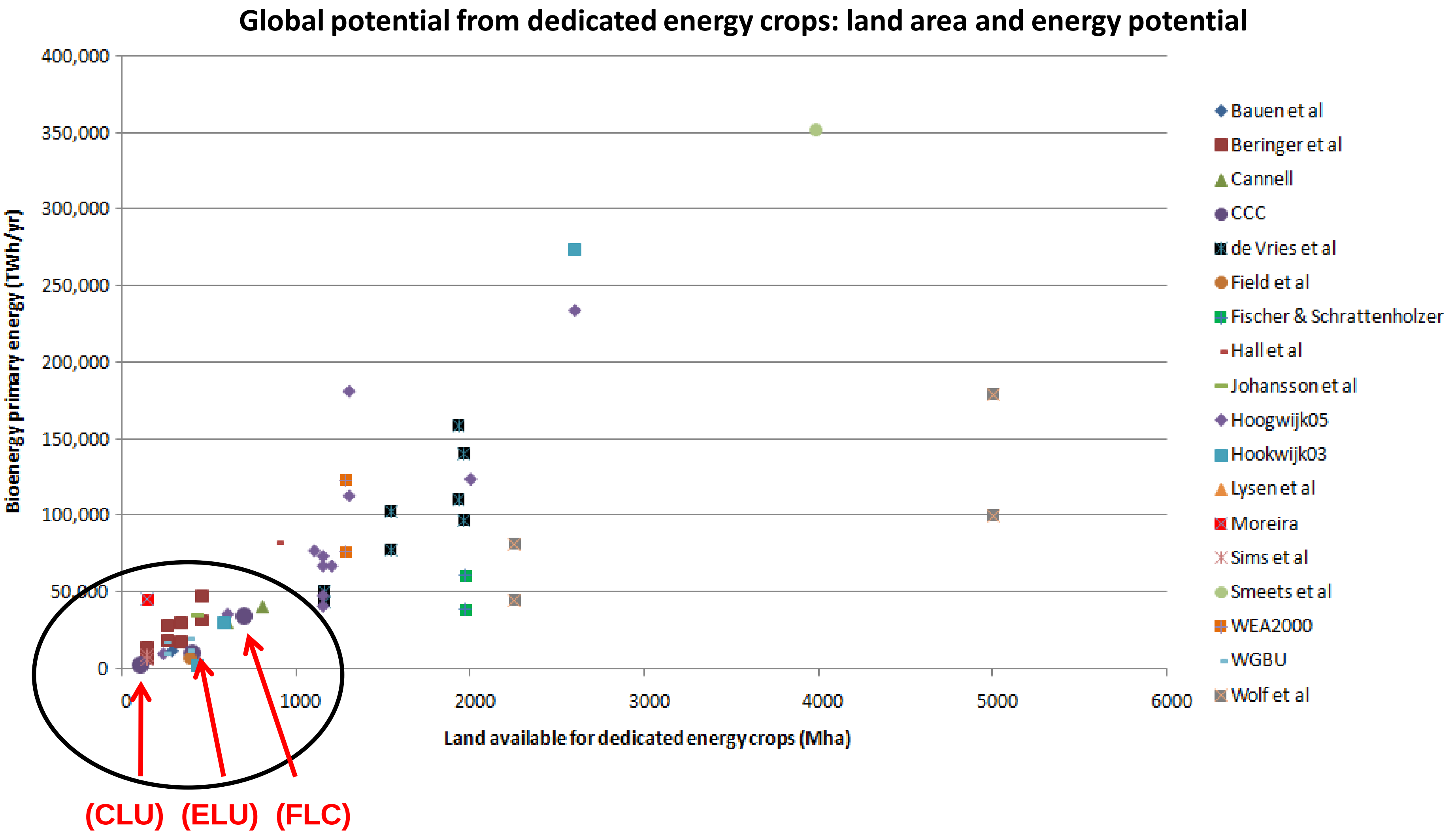
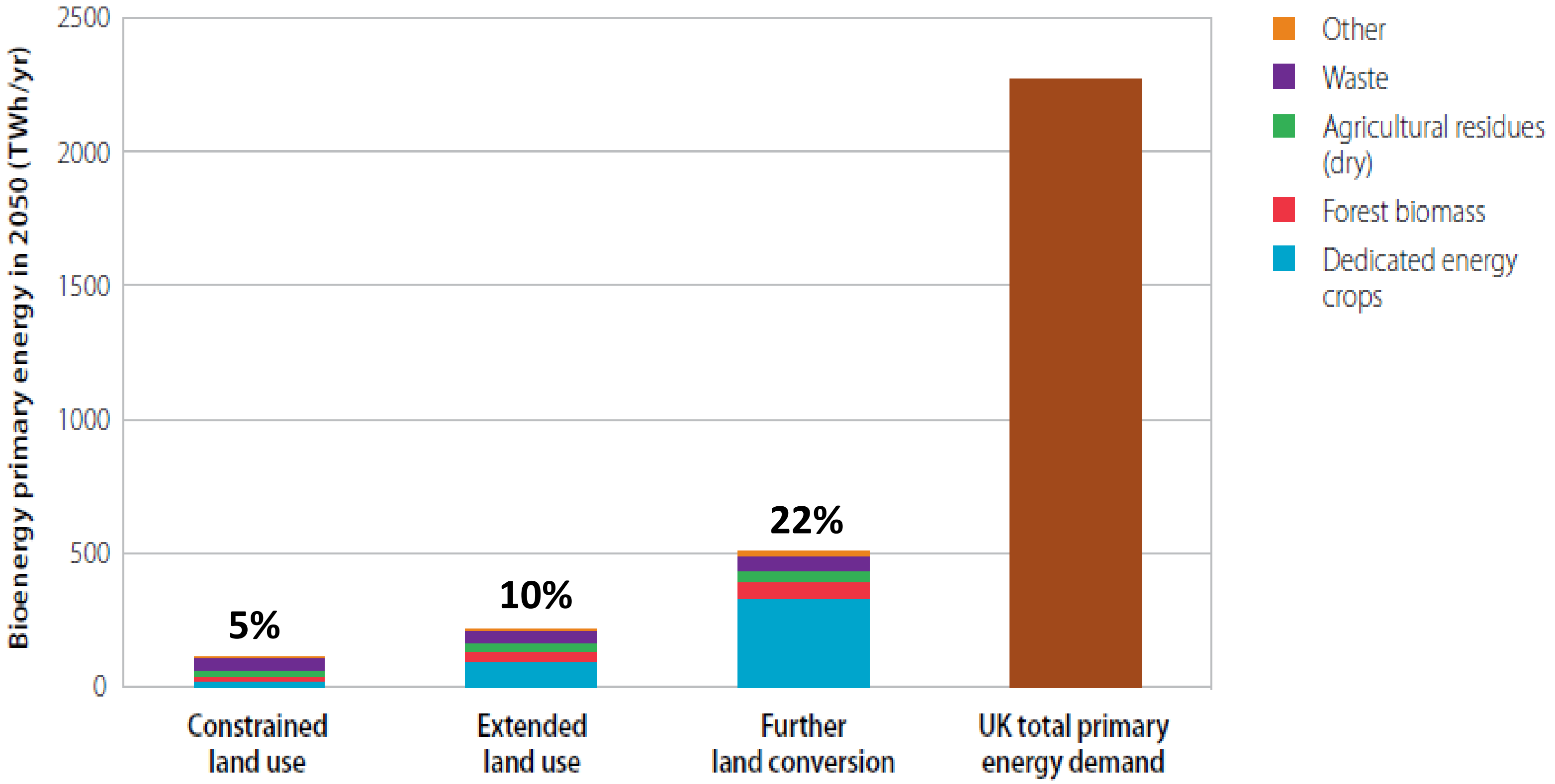


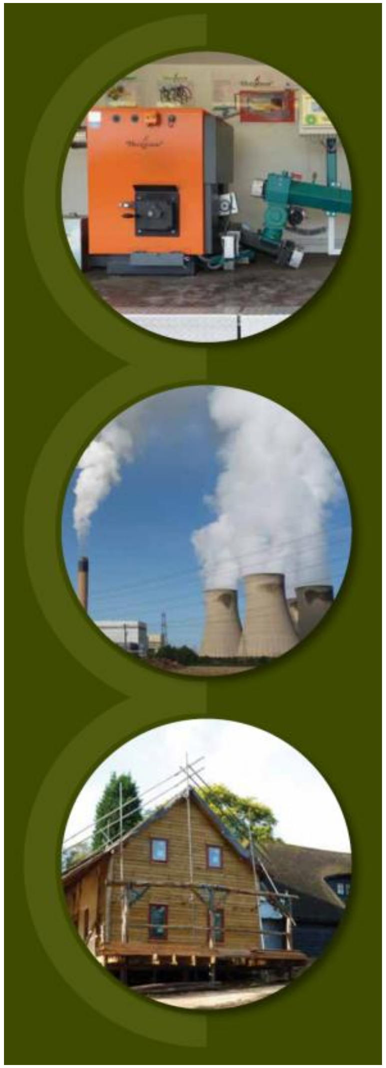

Chart adapted from Slade, et al., (2011)

# Our UK scenarios give a range of bioenergy penetration in 2050 from 5 to 22% of primary energy demand



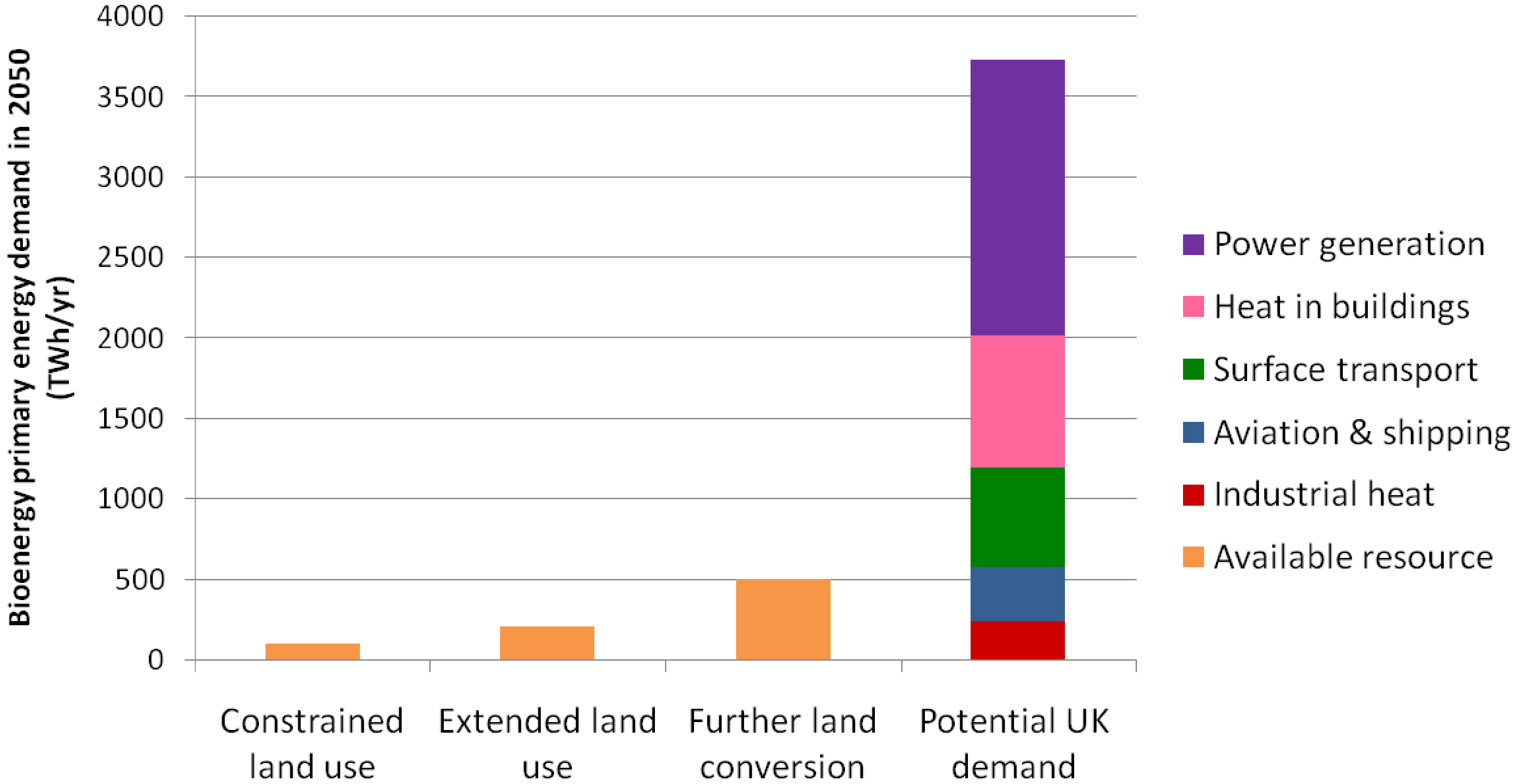

Our analysis suggests that a **reasonable** share of potential sustainable bioenergy supply could extend to around **10% of primary energy demand in 2050**.
Unsafe to assume higher levels of supply and even the 10% might require some trade-offs with other desirable objectives (e.g. biodiversity loss).

# Contents



1. Context:
2. Key messages of today's report
3. Is bioenergy low-carbon?
4. Sustainable bioenergy supply
5. Appropriate use of scarce bioenergy
6. Key conclusions

# Limited supply relative to potential demand mean trade-offs between sectors will be required



# Scarce bioenergy supplies should be allocated where they are most highly valued

Committee on Climate Change

Energy service demands

Bio supply

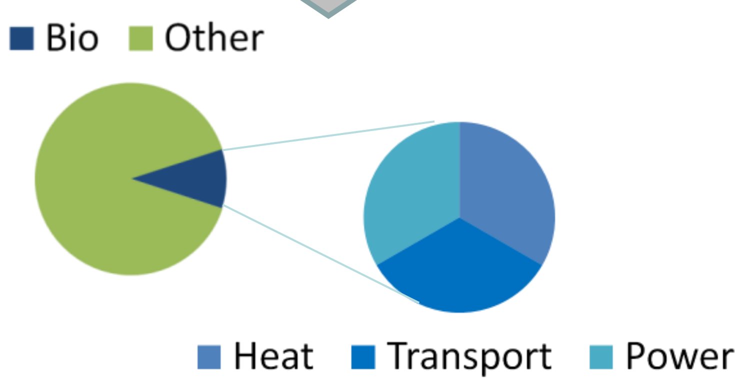
Available technologies

$CO_2$ emissions constraint

after efficiency improvements

Least cost optimisation

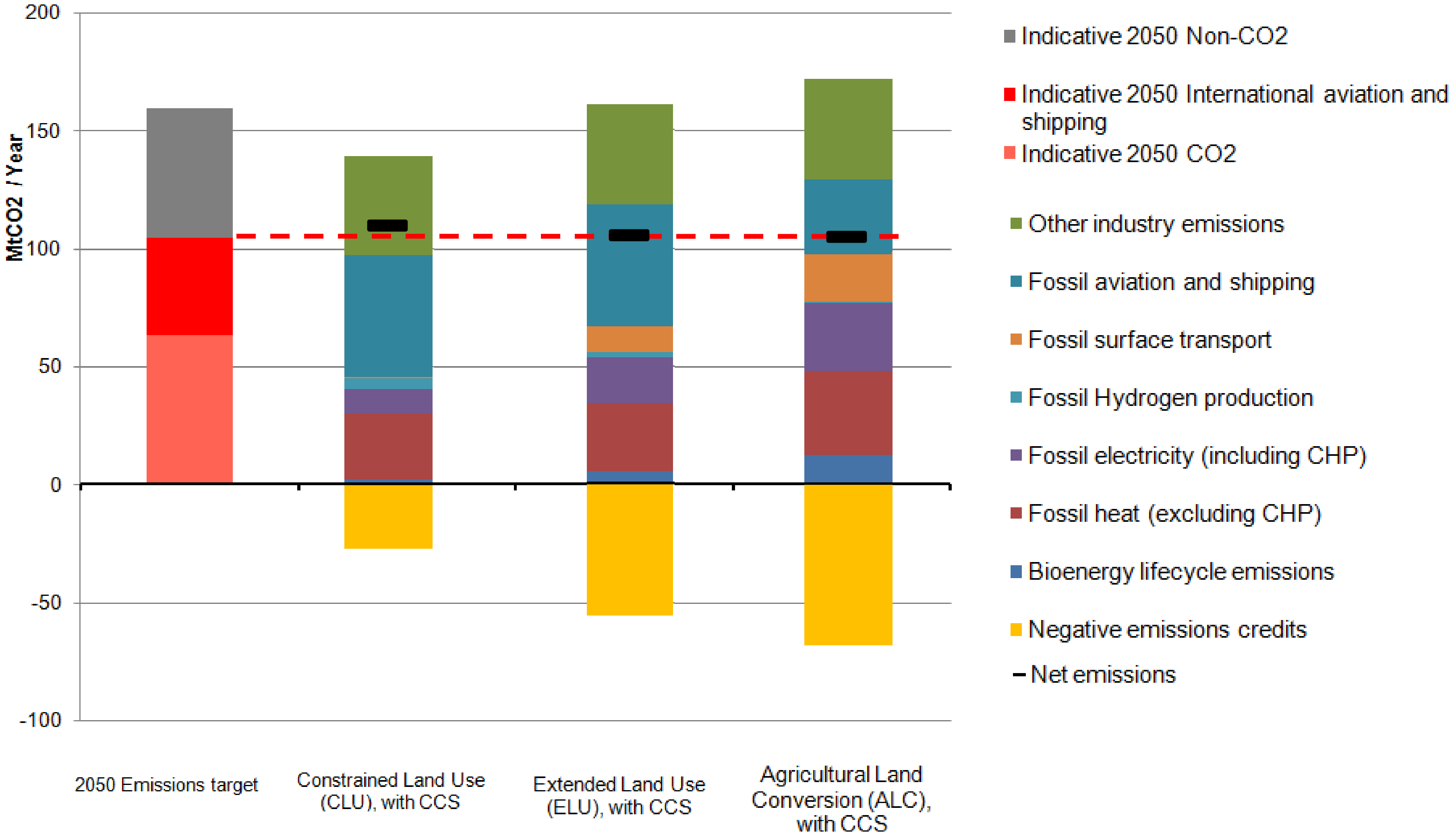
Full bioenergy lifecycle emissions included



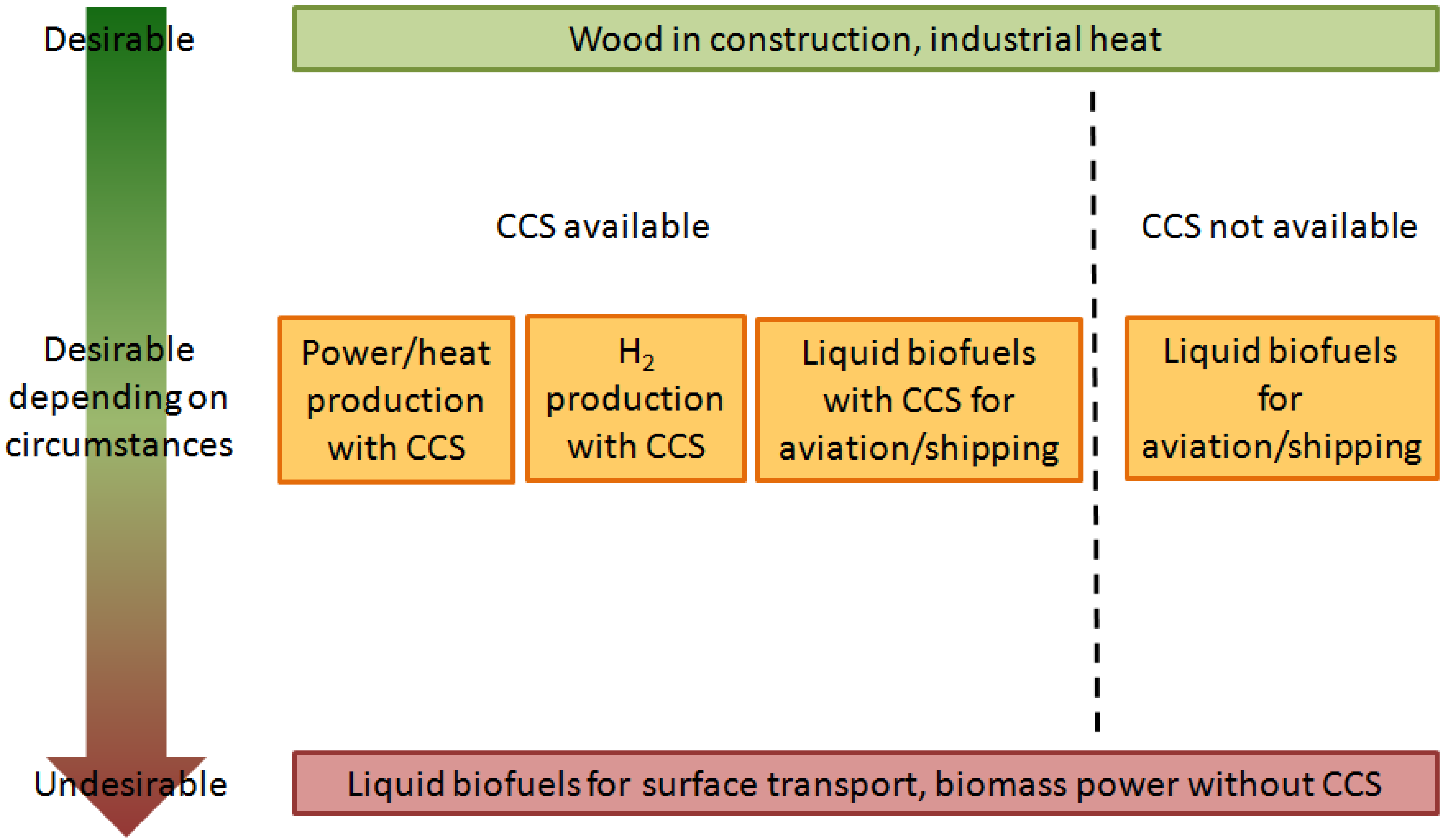

Aim to identify robust strategies across the range of abatement options and uncertainties

# 10% bioenergy penetration together with CCS will be required to meet long term targets

Committee on Climate Change



# Hierarchy of appropriate use



# Power sector implications

**Long-term** (large-scale power generation)

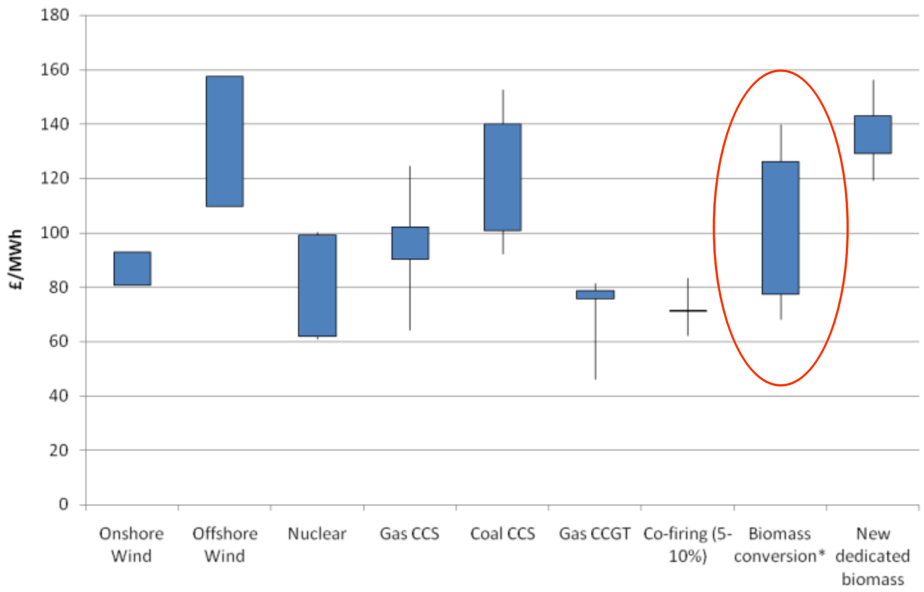
👍 If CCS viable

👎 If CCS not viable

**Short-term**
Transitional role to meet renewables target

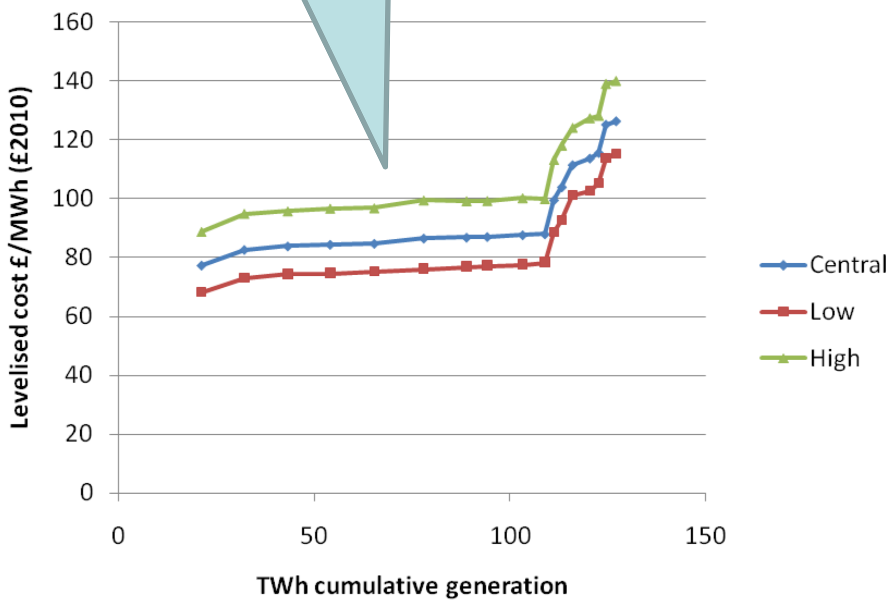
**Options**:
New large-scale dedicated plants
Co-firing /conversion of existing coal plants
Small-scale plants (using local resources)
Combined heat and power plants (e.g. using biogas)

# Conversion vs new, dedicated biomass power plants




**Key finding:**
There is a significant cost-effective opportunity for biomass conversion and co-firing, but not new dedicated biomass plant

**Conversion**: Over 100 TWh of generation at 80-90/MWh (central fuel prices) - enough to meet Renewables Roadmap ambition



# Power sector conclusions

UK Govt is proposing 1.5 ROCs for new dedicated plant versus 1 ROC for conversion / enhanced co-firing.

But Scottish government has proposed to limit support to small-scale plant and CHP.

Proposed levels of support under RO risk new capacity at considerable additional cost to consumers (e.g. 3-4 GW in the pipeline would cost consumers £175 million/GW/yr)

We recommend a focus on co-firing/conversion, some small scale / CHP but no / very limited support for new large scale biomass

Additionally should increase required emissions saving from 285 $gCO_2$ / kWh to 200 $gCO_2$ / kWh)

# Key conclusions for appropriate use

Committee on Climate Change

- Wood in construction and industrial heat are always desirable. For other uses, the availability of CCS is a key determinant of how desirable they are.
- **Power sector:** very limited role for new biomass power plants without CCS
- **Industry**: clear role for the long-term use of bioenergy in energy-intensive industry
- **Aviation and shipping**: important in world without CCS, otherwise depends on the viability of CCS in aviation/shipping biofuel plant
- **Surface transport** : transitional use with only niche use of biofuels in the long-term; possible use of hydrogen from bioenergy with CCS.
- **Heat in buildings and biogas:** role for biomass boilers in off-grid areas and combined heat and power using local resources (e.g. waste anaerobic digestion)
- A range of small-scale applications using local resources are also sensible

# Contents

# Summary - key conclusions

Committee on Climate Change

- Around 10% bioenergy penetration plus CCS may be required to meet the 2050 target, and could be sustainable:
  - Lower penetration requires unforeseen technology breakthroughs or radical behaviour change
  - Higher penetration would be unsafe from a sustainability perspective.

- Lifecycle emissions of bioenergy can be significant – regulatory frameworks at EU and UK levels need to be strengthened to make sure bioenergy is truly low-carbon.

- Bioenergy is a scare resource and should be used to maximise abatement :
  - without CCS: wood in construction, industrial heat, aviation and shipping
  - with CCS: wood in construction, various CCS applications
  - not in power without CCS or cars and vans

- Key priorities should be to develop CCS, develop bioenergy options, invest in a range of other low carbon technologies (e.g. electric vehicles, heat pumps).

http://www.theccc.org.uk/reports/bioenergy-review