The feasibility and costs of pyrolysis-biochar systems in North Sea Region of Europe: a case study on UK and Preliminary Analysis of Other NSR Countries

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Questions that are addressed

- How much do we know about the costs of producing biochar?
- What would biochar have to be worth in order to make its production and deployment break-even? (the ‘break-even selling point’)
- How can the provisional cost of biochar be used to produce a marginal carbon abatement value for different feedstocks?

Scenarios for available feedstock, biochar supply and technology scale

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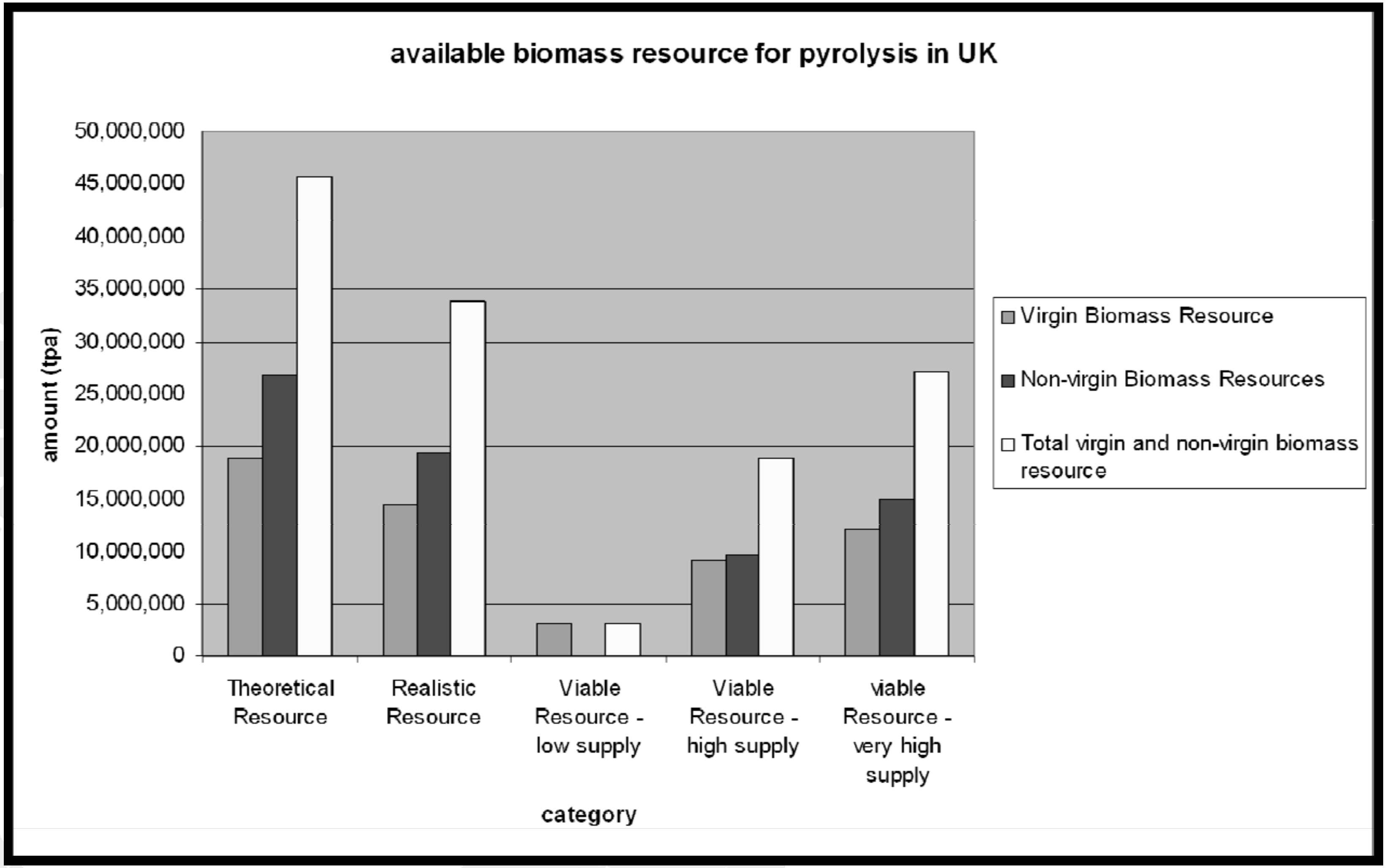
- Feedstock availability scenario:
  - Theoretically available resources
  - Realistically available resources
  - Viably available resources

- Biochar supply scenario:
  - Lower, high and very high supply of feedstocks available for pyrolysis (from viably available quantities)

- Scale of pyrolysis technology:
  - Small (~2000 oven dry tonnes per annum)
  - Medium (~16,000 ODTPA)
  - Large (~185,000 ODTPA)

Supply Scenario: Biomass for Pyrolysis



Summary of costs and benefits associated with pyrolysis-biochar systems (assuming that the biochar does not contain contaminants)

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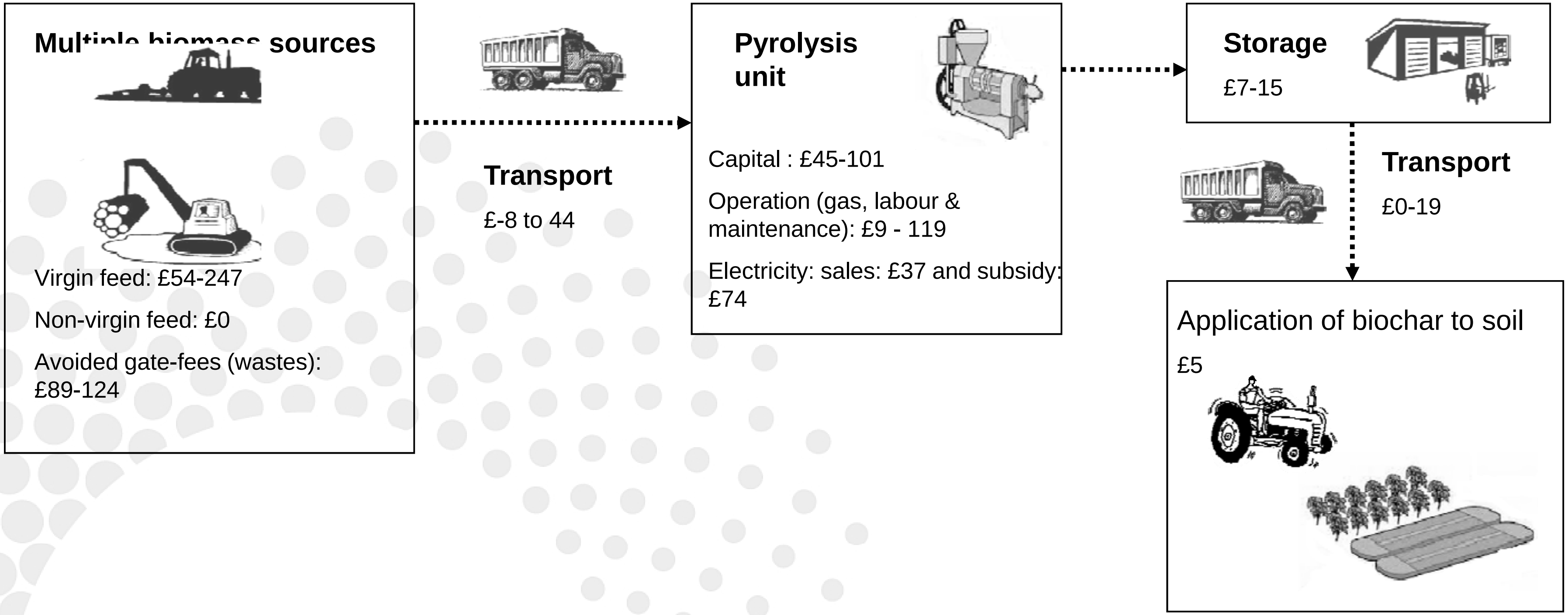
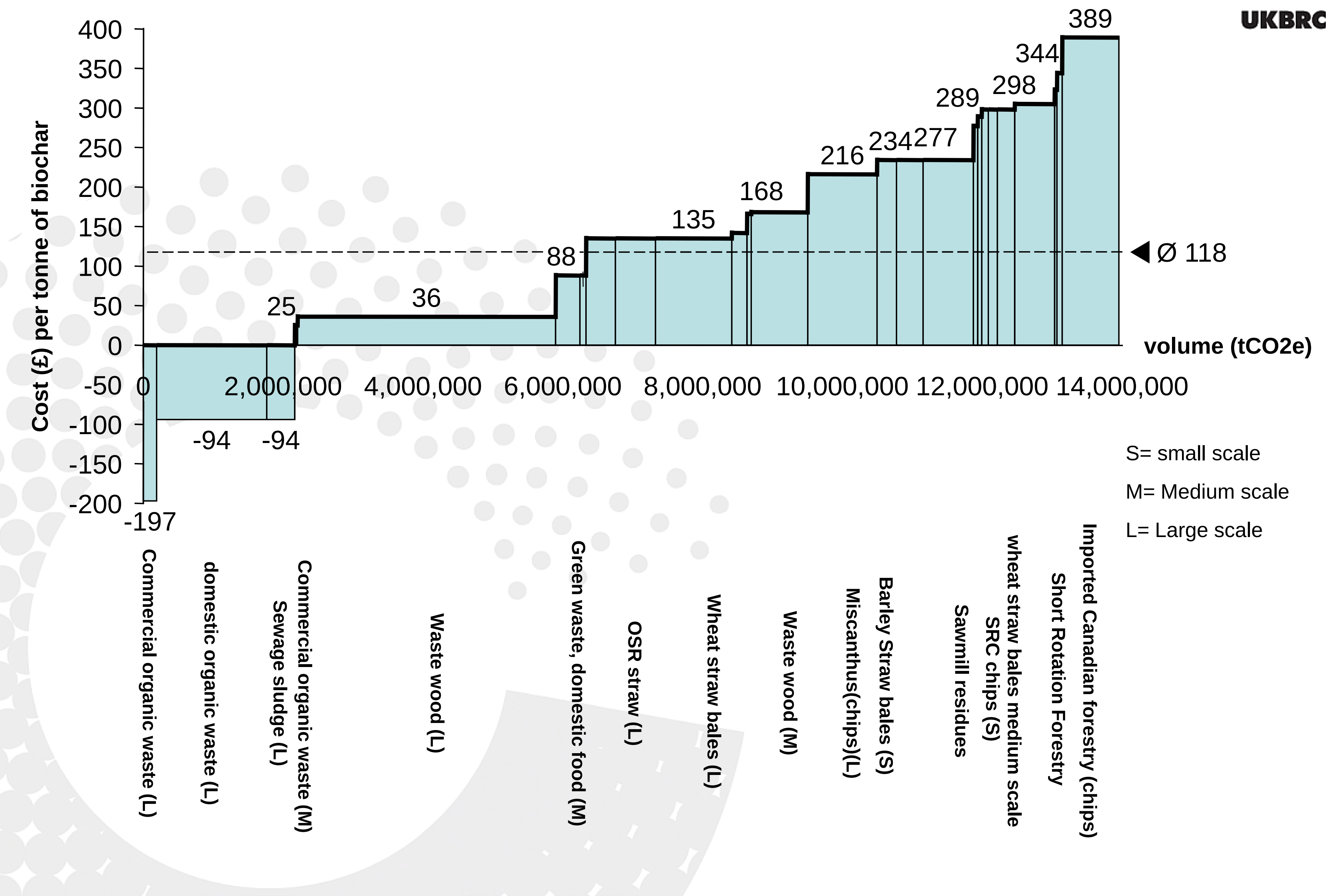
Total costs: Cost of producing , delivering and applying biochar			Total benefits: Value of biochar			
Biochar Production	Transportation & storage	Application	Energy production	Agricultural gains	Carbon storage	Diffuse pollution abatement
Feedstock Transport Utilities Maintenance & operation Labour Capital costs Gate fee	Equipment Labour New covered storage facilities	Equipment Labour Monitoring, verif-ication, reporting	Electricity value Heat value	Yield gain Quality Reduced fertiliser Soil workability Water retention	C abatement	Reduced nitrate run off



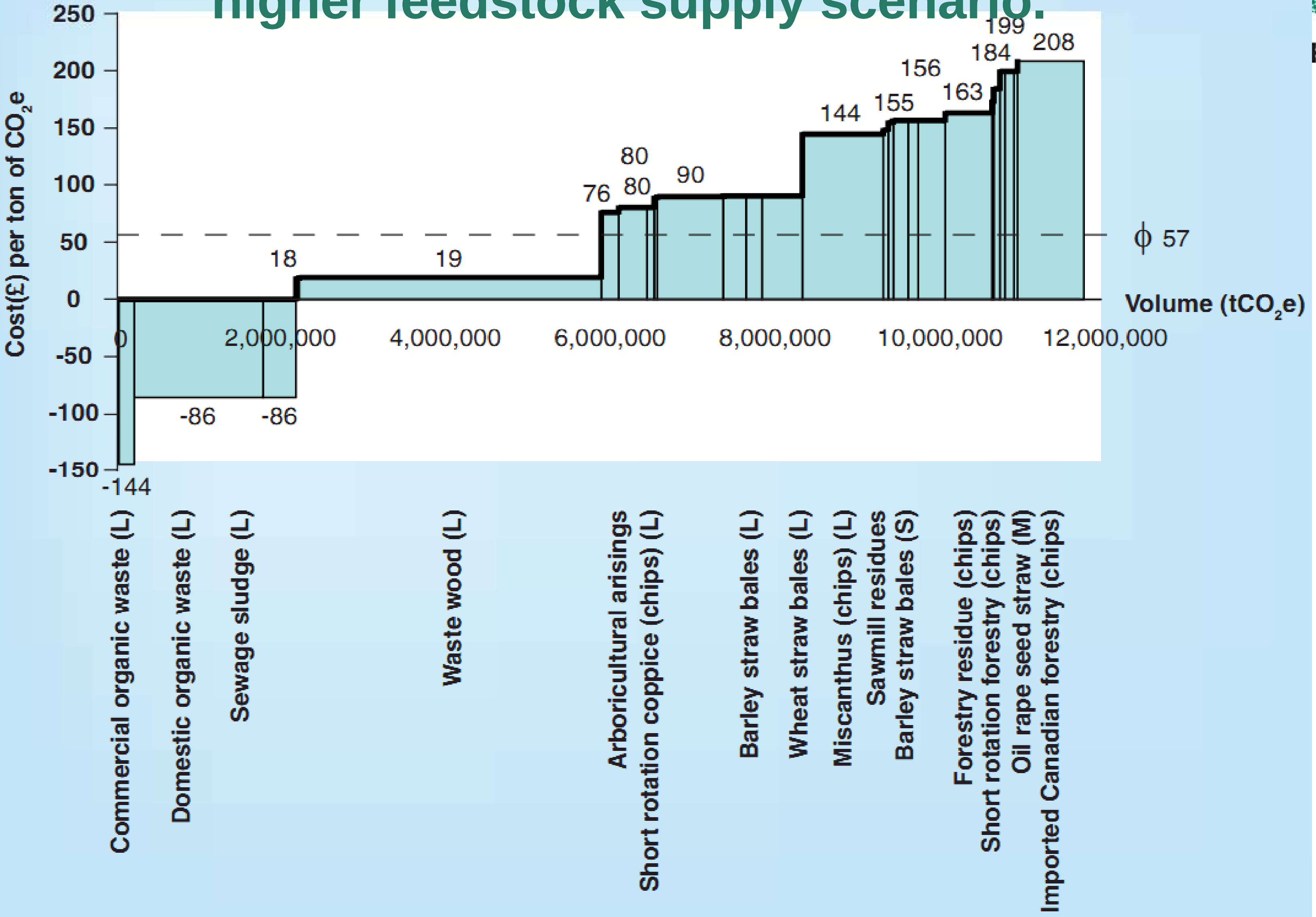
Pyrolysis-biochar system (PBS): from source to sink

Numbers indicate cost ranges (in £t^{-1} feedstock (biomass source, transport I, pyrolysis unit) or biochar (storage, transport II, application) per process stage)

Figure 7: Production cost curve for biochar from different feedstocks (cost in £ per ton versus quantity of CO2 abated).



Biochar marginal abatement cost (GB£tCO_2e^{-1}) for higher feedstock supply scenario.



Values do not include indirect effects of biochars in soils on net CO2 equivalent abatement.
L: Large scale; M: Medium scale; S: Small scale.

Revenue (left hand side) versus costs (right hand side) for a range of feedstocks

Methodology and Data Sources

- The real costs were provided for a medium-sized demonstration plant, and estimated for the small- and large-scale unit by comparison with the demonstration unit as well as existing plants.

- The **costs of producing biochar in the UK** context range from between **£-148 per tonne to £389 per tonne** delivered and spread on fields - a provisional **carbon abatement cost of -£144 tCO_2 per t to £208 tCO_2 per t** for a 'higher' resource scenario. (A negative cost indicates a profit-making activity).

- Carbon abatement values from Life-Cycle Assessment for specific feedstocks in UK context (Hammond et al., *Energy Policy* (2011), 39: 2646-2655. Assumes that 68% of the carbon in biochar is recalcitrant in the long term.

- Detail on existing results: paper in *Carbon Management* (2011), 2(3), pages 335 – 356.

Key Findings

- The largest sources of revenue are from electricity generation and from received gate-fee for wastes.
- Biochar from imported wood chips, miscanthus and short rotation forestry are among the most expensive types, while straw-based biochar is close behind.
- Wood waste and green waste-derived biochar are much cheaper (with a carbon abatement cost from (-£144 per tCO_2 to £19 per tCO_2).

Analysis of the costs

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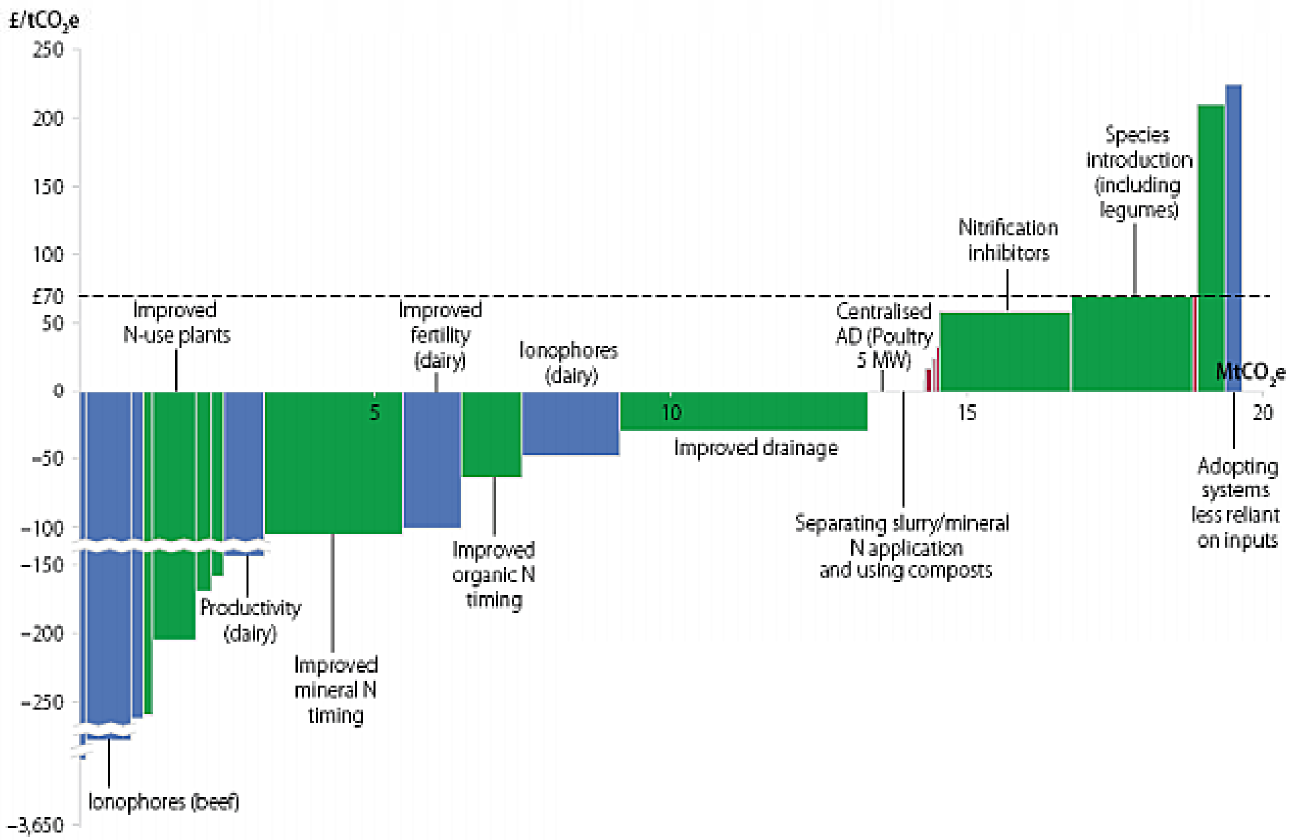
- Largest contributions to costs are: capital, feedstock and operational.
- Small-scale biochar production benefits from lower transport cost, large-scale production from much lower capital and operational costs.
- Avoided gate fees provide an important revenue stream when non-virgin feedstocks are utilized.
- Transport costs for non-virgin feedstocks are also low.
- Therefore use of non-virgin biomass waste resources provides a much more favourable economic outlook for a PBS.
- But pyrolysis of such materials will probably pose greater risks and more difficulty in addressing regulatory questions and issues and thereby requires concerted effort on the risk assessment and appropriate regulation of the resultant biochar.

There are cheaper carbon abatement options in UK agriculture to 2030 ……



Source: SAC modelling for CCC

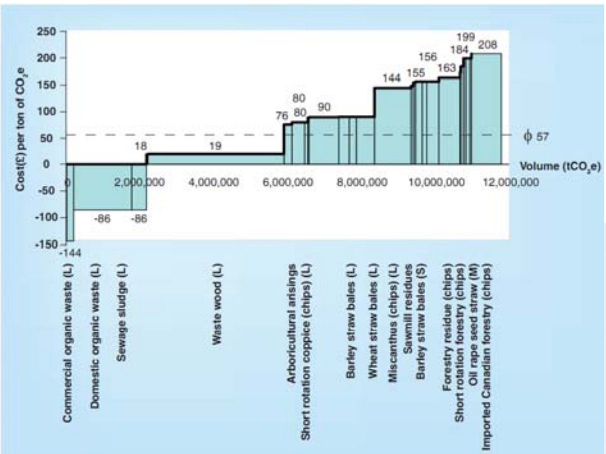
- 4-14 $MtCO_2e$ from known options in 2020

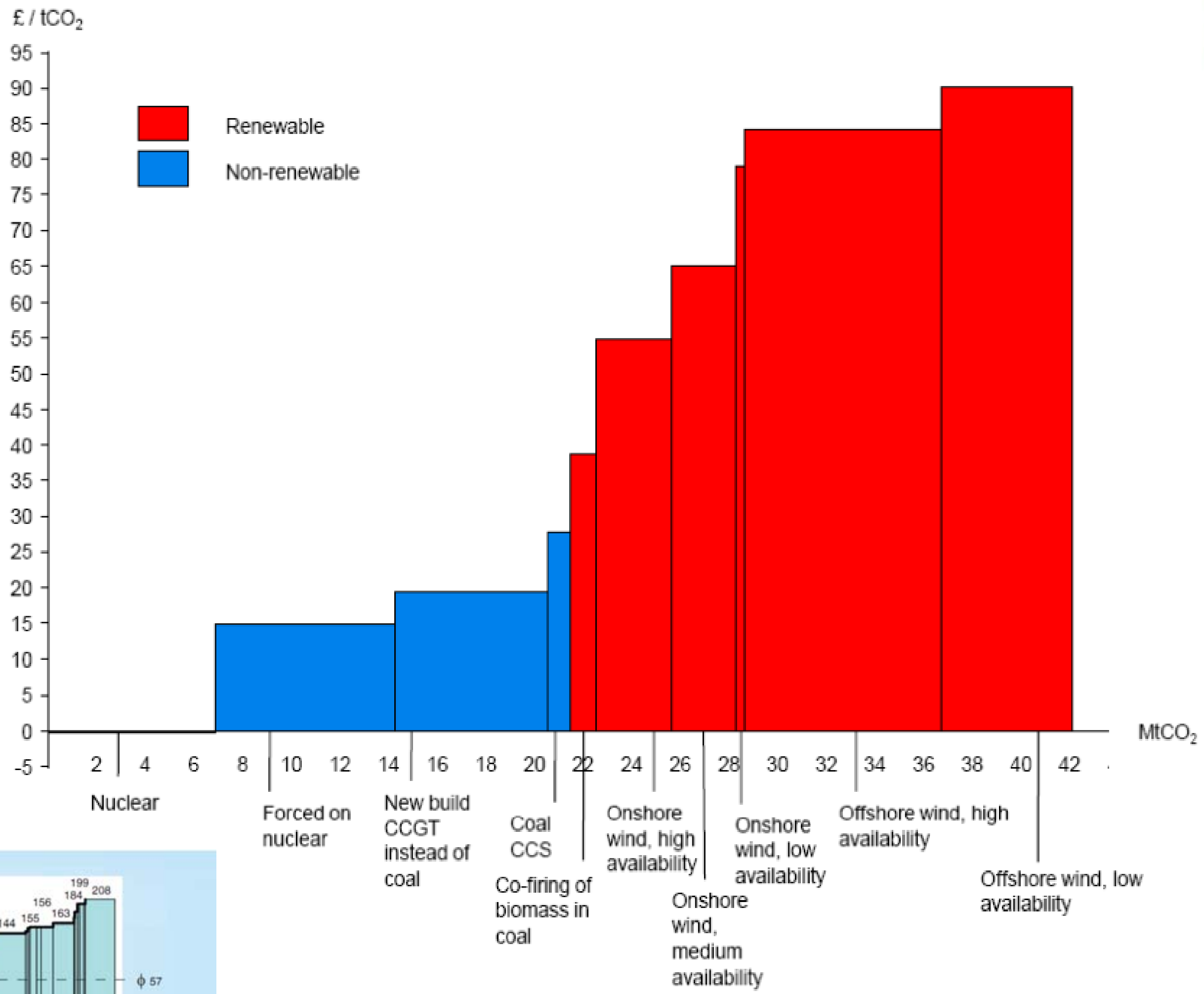
<u>**Less certain options**</u>

- **Additional soil and livestock management practices** (e.g. improved animal health)
- **More radical biotechnological options** (e.g. GM methods to improve nitrogen use efficiency for crops)
- **Changed agricultural systems**
- **Demand-side measures** (e.g. reducing food waste and rebalancing diets)

Carbon abatement in the power sector also has some cheaper options, but may not be accepted

Biochar MACC





Power sector MACC (Source: CCC Modelling.)

Note: ‘Forced on’ plant refers to plant which is built despite the existence of enough generation capacity on the system (e.g. to meet a target). It therefore displaces existing plant rather than new plant.

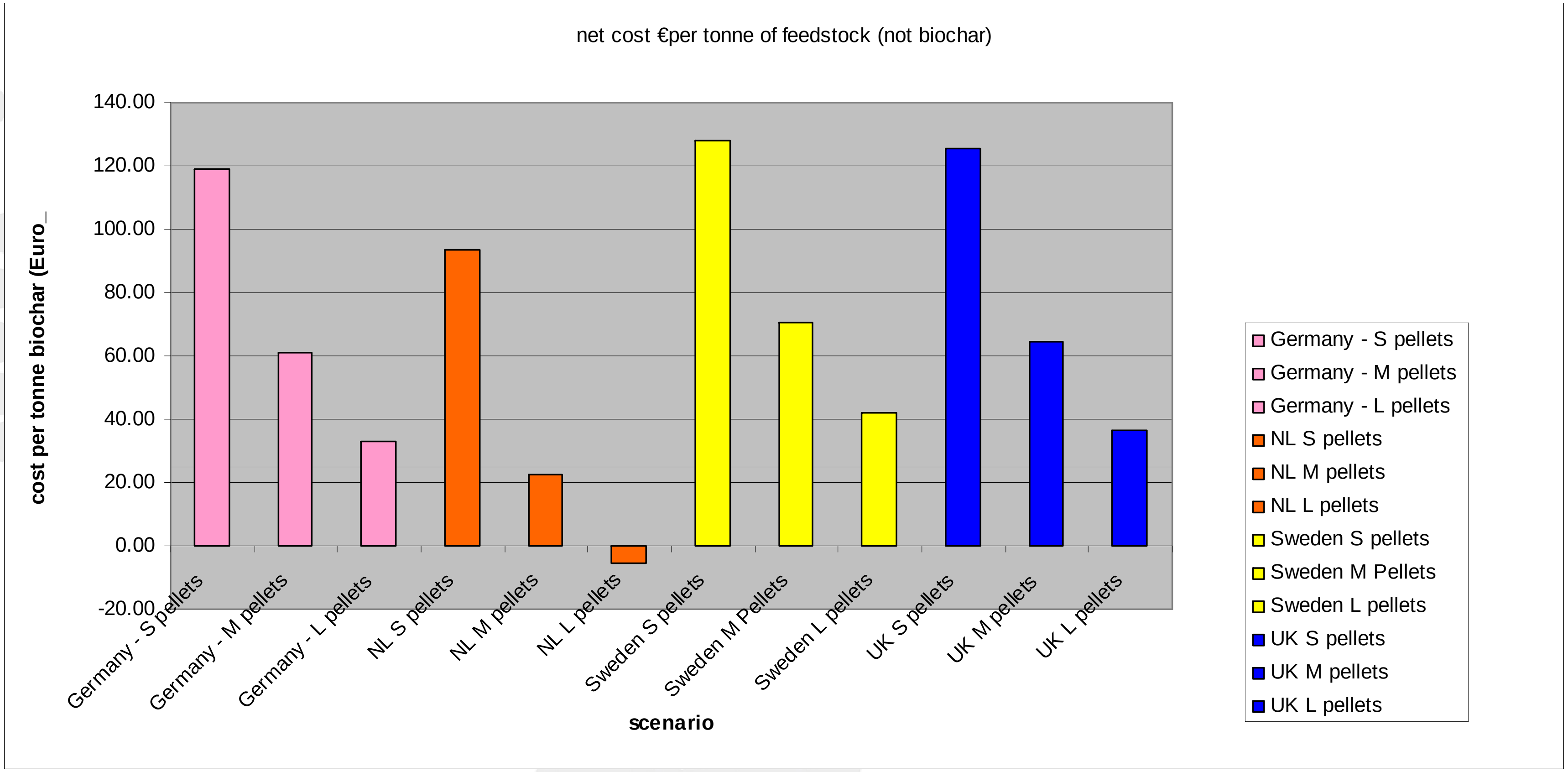
North Sea Region Costs Comparison: An optimistic view looking forwards

- Feedstock costs broadly similar in D, NL, SE, UK for wood pellets (c €130 per tonne)
- The main differences are: level of subsidy, with NL slightly greater; value of MWh generation, slightly lower in SE
- Taking optimistic view looking forwards as the technology matures and costs come down (technology learning curves)
- Assumes project lifetime of 20 years and interest rate of 8% - i.e. favourable lending context given high risk of new technologies

Analysis of Production Costs in Netherlands, Sweden, Germany, UK (per t feedstock)

- Preliminary analysis using capital and operational costs for small, medium and large scale plants in each country (per tonne of feedstock, capital: S €34, M €38, L €17; operational S €40, M €22, L €15).
- As yet not including transport, storage or application costs.
- As yet only for wood pellets.
- Precise value of subsidies unclear and changing in some jurisdictions (e.g. UK with Energy Market Reform).

Production Costs from Wood Pellets: Germany, Netherlands, Sweden, UK



North Sea Region Costs Comparison and Next Steps with Interreg project

- Feedstock costs broadly similar in D, NL, SE, UK for wood pellets (traded commodity)
- The main difference is in level of subsidy, with NL slightly greater, and revenue from electricity generation slightly lower in SE.

To do …..

- Feedstock availability and cost data for the 7 Interreg countries
- Transport, storage and application costs in each country

Next Steps with Interreg NSR Work

- Revise capital and operational costs
- Technology scaling effects and learning curves
- Look at likely / possible changes in incentive regimes for electricity and heat production through policy scenarios
- Create Marginal Abatement Cost Curves for each of the 7 Interreg countries
- Develop comparable analysis for main alternative applications of biomass to compare cost differentials and plot on same MACC – i.e. co-firing with coal, dedicated biomass, AD, gasification
- Consider extending to HTC

Key Conclusions

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- No policy incentive for carbon abatement value of biochar
- Hard to see how such an incentive can develop from existing EU and many national-level incentive schemes – these tend to incentivise renewable electricity generation efficiency not carbon abatement efficiency
- Closest parallel is CCS which is included in EU ETS but only applies to companies with generation threshold (>20MW) > achieved by high-level lobbying in Brussels by major companies, governments and NGOs.

Key Conclusions

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- Growing competition for biomass and organic wastes – espc co-firing and dedicated biomass combustion
- Therefore reduce production cost or increase product value or both
- Innovation scholars argue that new technologies emerge through development in 'niche' – a small number then become part of the dominant socio-technical regime
- What might be biochar niche? – specialist waste mgt options; processing of residues from new industries of bio-refineries.
- Problems in the Kyoto and voluntary carbon markets - how to resolve?

Thank you for your attention. Any questions?

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