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EU Transport GHG: Routes to 2050?

Technical Options and Alternative Energy Carriers for Rail

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Partners

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Scope of Presentation

- Technical options for Rail
 - Mass reduction
 - Regenerative braking
 - Electrification
 - Aerodynamics and friction
 - Improved air conditioning
- Alternative energy carriers for Rail
 - Fuel cells and hydrogen
 - Liquid biofuels and biogas
 - CNG, LNG and LPG
- Conclusions
- Data gaps

Points to note

- Based on Paper 3 – Technical Options to reduce GHG emissions from non-road modes
- Lead Author was Tom Hazeldine (Summaries + Rail Chapter)
- Data gaps highlighted in red and summarised at the end of the presentation

Mass reduction

- Reduces fuel consumption and wear on tracks
- Mass reduction opportunities exist:
 - Double deck trains (10% weight saving on a single vehicle, CE Delft 2005)
 - Aluminium railcar body (2% - 5%)
 - Wide-body trains (10%)
 - Articulated trains (2% - 5%)
 - E.g. Jakob style bogies
 - Lightweight coach interior equipment (2% - 5%)
- What does a 10% weight saving equate to in terms of GHG emissions?
 - 5% to 7.5% fuel saving, IFEU Heidelberg
 - 1.2% for high speed trains and 6.4% for suburban trains, CE Delft
- Costs
 - No data available
- Barriers
 - Cost effectiveness
 - Lifetime of rolling stock
 - Will limit opportunities for weight reduction
 - Leads rolling stock owners to be cautious when investing in new technologies

Regenerative braking

- Reduces energy demand and hence GHG emissions
- Yet to reach a consensus on what to do with regen electricity
 - Store onboard, store trackside or feed back into the Grid.
- Different views on potential GHG savings
 - 10% to 15%, UK Railway Forum
 - 6% to 30%, RSSB
- Costs
 - No data available
- Barriers
 - % of rail vehicles fitted with regen braking
 - Asset life (rolling stock and infrastructure)
 - DC networks limit ability to make use of regen electricity
 - Range of stakeholders involved so decision making can be slow

Electrification

- Various benefits to electric traction:
 - Quieter
 - Cheaper to lease/buy and maintain
 - Greater number of seats
 - Reduce air quality emissions at stations
 - Improved energy security
- 80% of traffic already carried by electric traction
 - But only 51% of tracks electrified...approaching limit of cost effectiveness?
- Greatest GHG reduction opportunity even with current energy mix
 - 20% to 40%, Railway Forum
 - 20% to 30%, Network Rail
- Cost
 - £550k to £650k per track km, Railway Forum
- Barriers
 - Capital costs – Government support likely to be required

Aerodynamics and friction

- Sources of aerodynamic drag
 - Bogies and wheels: 45% (Anderson and Berg, 1999)
 - Surface friction from sides and roof: 27%
 - Pantograph: 8%
- Anderson and Berg also suggested a range of options for reducing drag
 - Bogie covers
 - Streamlining of train sides and underfloor areas
 - Aerodynamic optimisation of pantographs
 - Aerodynamic ordering of freight cars
 - Covers for open freight cars
 - Streamlining of head and tail
- Bogie covers were found to reduce drag by 10% which equates to a fuel saving (and GHG saving) of 6% to 7%
 - No data on GHG savings from other measures
- In view of modest fuel/cost savings associated with most aerodynamic measures they are most suitable for new trains
 - No cost data for any measures

Improved Air Conditioning

- Measures to reduce energy use from air con during stabling (RSSB, 2007):
 - Heat to a lower temp for majority of the time when the trains is stabled
 - Switch off heating at shutdown and restart before train re-enters service
 - Provide heat for cleaning, but turn off as soon as cleaning is complete
 - Provide trace heating on components/systems that require to be kept above a minimum temperature (e.g. on water systems)
 - Provide a more efficient auxiliary power source
- Measures for reducing energy use from air con whilst the train is in use:
 - Reduce uncontrolled air ingress or draughts
 - Improve insulation of rail vehicles
 - Reduce solar gain through use of specialist paints
 - Changes to interior temperature set points
 - Reduce fresh air intake
- GHG and cost savings if all above measures implemented in UK
 - 4% fuel saving, 101,000 tonnes of CO₂, £13.2m cost saving
 - **More GHG / cost data welcomed**
- Barriers:
 - Modest fuel/cost savings therefore little incentive to invest capital

Fuel cells and hydrogen

- **Benefits**
 - Improved energy security
 - Combination of lower GHG emissions than diesel and ease of storage
- **Fuel cell powered rail vehicles are being tested**
 - East Japan Rail Company, railcar
 - Denmark (2010), railcar
 - BNSF in the US, shunting loco
- **Cost and GHG savings for a class 66 locomotive, RSSB 2005**
 - Fuel cell power train = £344k (vs ~£250k for a diesel power train)
 - Hydrogen storage = £1million in 2005, reduced to £200k by 2010?
 - 2% switch from diesel to hydrogen would save 4,500 tonnes CO2 in the UK
- **Barriers**
 - Additional capital cost
 - Operational lifetime of fuel cells not sufficient
 - Inherently less energy efficient than pure electric traction
 - New infrastructure required – diesel/electric infrastructure well understood and in place

CNG, LNG, LPG

- Similar GHG emissions to diesel
- Main benefit is reduced pollutant emissions (CO, NO, HC, PM) vs diesel traction
- Costs
 - No data available
- Barriers
 - CNG/LNG
 - Medium to large engines only available for stationary applications
 - Low energy density and hence reduced range and/or packaging issues
 - Would require expensive new refuelling infrastructure + possible conflict with hydrogen?
 - LPG
 - No engines available and diesel engine conversion would be complex

Liquid biofuels and biogas

- **Some strong drivers**
 - 38% to 64% GHG savings for biodiesel from oilseed rape
 - Renewable Energy Directive
 - Mandatory 10% of transport fuel from biofuels by 2020
- **However...**
 - Biodiesel is only used in 20% blend (B30 may increase lifecycle costs)
 - 80% of rail tonnekm and passenger kms are via electric traction
 - Therefore, overall GHG reductions will be limited
- **Costs**
 - Biodiesel is significantly more expensive than conventional diesel
- **Barriers**
 - Sustainability issues
 - First generation biofuels use food crops
 - Emissions savings are country-specific
 - Direct and Indirect Land Use Change can increase emissions elsewhere
 - Increased fuel consumption
 - Decreased power

Conclusions

- Further electrification will achieve the greatest GHG savings
 - And will 'lock in' further reductions as Grid is decarbonised...
 - ...but 'diminishing returns' will become an issue
- Regen braking offers *potential* for significant savings
- Biofuels will make a small contribution to GHG reductions via their mandated introduction
- Modest GHG savings could be achieved through mass reduction and changes to air con and aerodynamics
 - Likely to be limited to new trains
- For the foreseeable future the role of Hydrogen/fuel cells will be limited to niche applications such APU's (not traction power)
- No role for CNG/LNG/LPG for the foreseeable future

Data gaps

- Marginal capital cost of mass reduction, regenerative braking, aerodynamics and CNG/LNG/LPG
- GHG savings from aerodynamics and air conditioning measures

Questions to stimulate debate

- Do you agree with the GHG savings and costs for each measure?
- Do you agree with the conclusions?
- Can you help fill any of the data gaps?
- Are there any technical measures we have omitted?

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