Future Fuel for Britain’s Railways

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So what does the future look like?

□ Railways are in demand:
  – new railway lines including HS2, HS3, Crossrail …
  – more trains needed, with a 57% growth in capacity required by 2034
  – more stations & depots
  – much higher operating speeds (HS2 built for 250mph)
□ This requires substantially more power than the railways currently use, despite advances in technology
Where’s the power going to come from?

- Not from diesel:
  - global climate change concerns
  - increasing local pollution concerns (i.e. NOx and particulates)
  - advances in after-treatment help, but are not a solution
  - stability of supply
  - security of supply
  - train leasing companies won’t buy new diesel fleets

Source: Top Gear Magazine, 2015

So we're going to electrify everywhere?

- No – it’s too expensive
- There are also challenges in relation to the grid:
  - railways currently consume about 0.5% of grid capacity
  - but capacity to increase dramatically, more electrification & higher speeds
  - conceivable that electricity demand could double to 1% by 2034
  - but there’s not a lot of spare generating capacity and it’s likely to get worse
So what can be done about it?

- Reduce consumption:
  - improve train aerodynamics
  - reduced train mass
  - increased use of regeneration
  - limit maximum speeds
  - improve the energy efficiency of our buildings, stations, depots

- But there’s a limit to what can be achieved, so will still need to examine the alternatives

So what are the alternatives?

- Generate our own electricity (ideally local to rail infrastructure), and
- Find an alternative to diesel for autonomous power that is:
  - ideally not reliant on fossil fuels, or at least which produces less CO2
  - produces no NOx and particulate pollution
  - is suitable for both urban and non-urban environments
How do we generate our own electricity?

- Could build our own power stations, but we don't need that sort of power at a single location
- Smaller distributed power generation might be better:
  - solar can't provide the sorts of power we need
  - on-shore wind would require huge energy storage capacity
  - could use natural gas, particularly if fracking happens
  - could also use biogas

Source: Reuters website - 2013
Source: The Lincolnite website - 2015
Source: The Guardian website - 2012

So how can we use natural gas / biogas?

- Could use CHP plants as per New Street which has a 1.5MW installation on the roof with excess heat feeding the local district heating system
- But this still produces NOx and particulates
- One alternative is to use Direct Fuel Cells (DFCs):
  - 59MW installation in S.Korea
  - constructed in 14 months by Fuel Cell Energy Inc.

Source: NewStreetNewStart website - 2015
What's a DFC and why is it a good idea?

- Natural gas (or biogas) reformed within a high temperature fuel cell:
  - generates electricity at 47% efficiency (gas turbines ≈ 40%)
  - zero NOx and particulates
  - lower CO2 emissions
  - virtually silent
  - high grade “waste” heat 350-400°C used to heat/cool buildings or boost electrical efficiency to over 60%
  - provides a plentiful supply of high-grade hydrogen, which could be useful ....


Alternatives for autonomous traction?

- IPEMUs (i.e. EMU + battery) wherever trains run mainly under the wires, but hop off to go short distances:
  - through tunnels
  - to cover non-electrified "end of the line" stations
  - to hop between electrified routes
- But there is still a need for trains that never need to "recharge" from the overhead
- UoB is keen on fuel-cells

Source: Rail Technology Magazine website - 2015
So why do fuel cells make sense?

- Hydrogen can be generated from a wide variety of sources
- Large quantities of energy can be stored
- Trains have known duty cycles and return to base every
- 100kW to 200kW fuel-cells available, suitable for 75mph regional services or light rail
- UoB looking at retro-fitting mid-life DMUs such as Class 150/3/6 to construct Britain’s first FCEMU

Any final thoughts?

- Could FCEMUs provide low cost alternative to electrification?
- Could a combination of DFCs, electrolysers & FCEMUs enable the Britain’s railways to run on only natural gas and off-peak electricity?
- Could railway stations become the “hydrogen hubs” of the future?