An Energy Hierarchy
with particular reference to waste carbon feedstocks

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Made today, gone tomorrow ?

Liverpool

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An Energy Gap in 2015/2020 ?

- **Coal-fired power stations : 2008 37% 'opted' out of LCPD (IED – 2020/2023)**

(coal imports ??, clean coal, 'capture-ready' new build or retro-fit, CCS by 2030 ?)

- **Nuclear power = from 11% to 4% of electricity after 2020 ?**

(cost, safety, waste, proliferation. 2019 for first new build (of 10) ? £20 billion ?)

(no 'uranium' bullet as an energy solution, reliance on private sector finance)

- **Gas = 80% imports by 2020 ?**

(geopolitics of supply, CCGT, can be stored – but less in UK than EU, GCS as well as CCS)

- **Renewables (wind 1-33+ GW?), new technologies, low-carbon, micro-generation, DE ?**

(will they deliver by 2015/2020 ? Efficiencies ? Grids (£32bn) ? <u>Baseload</u> and/or peak ?)

- **MSW, 10 m tonnes by 2020 ? But re-definition to include relevant C+I wastes**

2 mtpa of RDF/SRF by 2010 ? 26 mtpa by 2020 ? (10-17% of electricity ? and/or exports ?)

- **Cost (£50 billion + ?), timescales, land use planning, etc, etc**

National Renewable Energy Action Plan, July 2010

Hydro	**2.13 GW**
Solar PV	**2.68**
Wave + tidal	**1.3**
Onshore wind	**14.89**
Offshore wind	**12.99**
Biomass	**4.24**
Total	**38.21 (15% by 2020)**

Supported by

FITs, banding of ROCs, RHI, RTFO

Green Investment Bank

Community ownership

Smart Grids

CBI report, Action Plan for AD

A hierarchy of energy from waste ?

- Energy efficiency : waste prevention

- Source segregated biomass fuel (energy crops, waste wood, biowaste)
  - anaerobic digestion
  - power generation, co-combustion/co-firing, biomass boilers
  - biofuels

- MBT/MHT : dry recyclables (quality), + a fuel product (2 mtpa by 2010 ? 26 by 2020 ?)
  + Co-combustion of mixed residual waste (less NIMBY ?)
  - Cement kilns, industrial boilers, power stations ... ???

- Good Quality Combined Heat and Power + cooling (or 'CHCP enabled') + water recycling
  - 80% + efficiency, appropriate scale = decentralised generation and/or RDF 'feeders'

- Electricity from residual carbon (25% efficiency up to 34% ?)

- New technologies (still to be proven - pyrolysis/gasification ? plasma arc ? use of syngas ? hydrogen fuel cells ?

- Mass burn incineration without energy recovery
- Energy from landfill gas

Energy Efficiency : Waste Prevention

- **Finite energy resources + import dependency ... Hostage to fossil fuels**

- **Increased efficiency for coal firing : 32% to 50% + *(advanced super-critical, IGCC, oxyfuel, + CCS)***

- **BUT more stress on :-**
  - **Product design = 80% of environmental impact**
  - **Embedded carbon and de-carbonisation**
  - **Market Transformation Programme and labelling**
  - **Energy-using Products Directive**
  - **‘Smart’ grids and ‘smart’ meters**
  - **Behaviour : stand-by buttons**
  - **Fiscal instruments**
  - **Social equity + fuel poverty**
  - **Buildings (insulation, boiler replacement, ‘smart’ meters, ‘smart’ lights)**
  - **Old vehicle ‘scrappage’**

- **Coalition Energy Bill**

Source-segregated Biomass Carbon as Fuels

- Biomass energy crops as fuel (issues of use of water, food crops, NO_x)
- Wood waste as fuel : WRF + reuse, recycling + energy recovery
- Segregated C+I biomass (food waste as fuel) industrial complexes
- Source segregated MSW garden and/or kitchen food wastes as fuel (2% collected in 2007)
- AD
  - Long history of AD and sewage and agricultural manures/slurries
  - Biomass + sewage sludge (Leicester)
  - WIP New Technologies Demonstrator Programme + WRAP + Defra
  - IVC (batch, tunnel = use energy) increasingly linked to AD/gasification
- Small scale (5-20-50+ ktpa)
- Biofuels

Wood Waste as a Fuel

- **Sources**
  - **Managed woodlands (additional 2 million tonnes by 2020)**
  - **Wood industry**
  - **Waste wood (C&I = 4.5 million tonnes, C&D = 5.0, MSW = 1.0)**
  - **Imports of wood chips (>17 million tonnes ? >2,000 MW ?)**
    (North American pine beetle problems)

- **Options**
  - **Wood fired boilers (replacing coal)**
  - **Wood and co-firing (e.g. Drax + coal, + energy crops)**
  - **Wood fired CHP, but fewer proposals**
  - **March 2010, 7 = planning permission, 50 proposed**

- **Issues**
  - **Forestry waste and non-C&D wood waste excluded from WID (auditing ?)**
  - **ROCS favour efw versus recycling**

Anaerobic Digestion

- 2008 Milk Road Map
  - On-farm livestock slurries (1,000 farms by 2010, long term aim of 40% from renewables)
  - Industrial dairy wastes + centralised AD plants (3 by 2015)
  - Water Industry (20% from renewables by 2020, including AD)
  - Added food waste = C&I+MSW kerbside collections (but waste licensing issues)

- In-house food industry AD could provide 20% of energy requirements ('polygeneration')

- Cleaning and refining syngas (biomethane) for use as a transport fuel

- 20- 50% of residential heating ? (ADBA, Nat. Grid report of 2009) – limited heat used now, storage ?

- PAS 110 Quality Protocol for digestate + Quality Protocol for biomethane

- 2009 – Defra = 80 mt of animal slurry, 18-20 mt of food waste, 1.7 mt of sewage sludge

- 2010 – Coalition : '... measures to promote a huge increase in efw through AD'

Some Concerns with Anaerobic Digestion

- **Feedstocks : manures, kitchen food waste not kitchen waste, C&I food processing + catering wastes, bio/biodegradable wastes, limited paper + card ... contamination, ABPR ?, bioplastics, contracts**
- **Planning : scale + catchment area, permitting, farm ... regional ... (multi) NIMBYism**
- **Handling : storage (caddies + bags), collection, health and safety (bioaerosols), de-packaging**
- **Energy outputs : wastes v. products, markets (power, heat, fuels, water), grids for gas, CRC ?**
- **Digestate + liquid outputs : PAS 110 (not PAS 100) as a biofertiliser, available landbank, licensing or exemptions, stability, odours ... substitute for oil-based fertilisers and $C0_{2e}$**
- **Underpinning science : which technologies (wet or dry, feedstock preparation) ,**

  UK context, agri/soil impacts
- **Fiscal support : grandfather rights, low values of FiTs + RHI**
- **2 per week to meet 10% of energy by 2020 (ADBA) ?**

  (February 2010 : 11 permitted, 2 in process, 51 in permit pre-applications)

  (June 2010 : 41 operational, 13 being built, 50 planned)
- **Food waste to livestock = x2 $C0_{2e}$ savings. Japan gives grants for this option**

Advanced Thermal Conversion/Treatment

- **Usually in the context of MBT/BMT (e.g. East London) or MHT (e.g. Merseyside)**

(using dry fibre as a fuel (as 'floc' or 'pellets' to meet client specifications, incl. composition) (rather than wet fibre for Anaerobic Digestion)

- **Extract recyclables (quality … markets ?)**
- **= (Semi) - residual waste treatment + diversion from landfill**
- **Autoclave (e.g. Doncaster, Cardiff, Tyneside, Wakefield) and MHT (Merseyside)**
- **Pyrolysis, gasification**
- **Plasma arc gasification (APP)**
- **Syngas, biomethane, ethanol, hydrogen**
- **Reference plants in the UK ?**

Residual Carbon = Residual Fuel/Energy Resource

- **Biogenic carbon and fossil carbon (limits to recycling of paper and plastics)**
  (> 50% paper exported. 37% of plastic bottles + 2% of mixed plastics recycled, 75% exported)

- **Wastes not targeted for separate collection (kerbside, banks) ... 10-30%**

- **Wastes not segregated by households (low participation)**

- **Contaminated wastes (including composites)**

- **Residues from collection and/or MRFs and/or processing ... including fines**

- **Other wastes : contaminated wood, household hazardous**

- **Residual MSW + residual commercial and industrial wastes**

- **"No reasonable prospect of the waste being recycled/composted" ... but carbon potential**

- **ERFs should be GQCHP = 60 – 200+ ktpa : proven technology, bankable**

‘Destructors’

The first municipal dust-destructors began operations in the UK in the 1870’s (Albert Fryer in Nottingham in 1874), partly in response to Public Health Acts of 1848, 1872, 1873, 1875, but the technology did not become widespread until the 1890’s, spreading quickly to nearly every large town in the UK. Over 300 by 1914.

Progressives proved enthusiastic advocates of refuse destruction, seeing the purificatory fires of the incinerator a hygienic and forward-looking technology that enabled refuse to be quickly removed from homes and neutralised as a source of disease.

Source : Cooper 2007. Challenging the ‘refuse revolution’ : war, waste and the rediscovery of recycling, 1900-1950.

(seen primarily as a method of hygienic waste disposal, reducing volume and weight, diversion from landfill, producing no methane and providing a resource in bottom ash)

WTE – EfW – EfRW – ERF ... Mass burn incinerators – direct combustion with CCHP

= Diversion from landfill, part of the solution, waste as an energy resource

Emissions

- Environmental Protection and Human Health (1990-2000)
  - Dioxin emissions from MSW in UK down 52% to 1% of total (0.5% in 2003, 2% from one EA study in 2004)
  - Dioxin emissions in MSW in Germany down 33% to <1%
  - Dioxin emissions in Germany down 400Tu to 0.5
  - WID dioxin limit down 225 to 0.1 ng 1-TEQ/m^3 = 99.9%
  - Metals + ultra fines ($PM_{2.5}$) = bigger problems ?
- Technology exists + tight emission limits + regulation + HPA
- "A Great Product but a Lousy Marketing Plan"
- Public perception and communication

Emissions

"The Health Protection Agency has reviewed research undertaken to examine the suggested links between emissions from municipal waste incinerators and effects on health. While it is not possible to rule out adverse health effects from modern, well regulated municipal waste incinerators with complete certainty, any potential damage to the health of those living close-by is likely to be very small, if detectable. This view is based on detailed assessments of the effects of air pollutants on health and on the fact that modern and well managed municipal waste incinerators make only a very small contribution to local concentrations of air pollutants (0.02% of PM_{10} and below). The Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment has reviewed recent data and has concluded that there is no need to change its previous advice, namely that any potential risk of cancer due to residency near to municipal waste incinerators is exceedingly low and probably not measurable by the most modern techniques. Since any possible health effects are likely to be very small, if detectable, studies of public health around modern, well managed municipal waste incinerators are not recommended."

Source : Health Protection Agency (February 2010). The Impact on Health of Emissions to Air from Municipal Solid Waste Incineration. (Similar to 2005 and 2009 Statements).

WID and new IED

Efficiency

- **Existing plant = > 0.6**
- **New plant = > 0.65**

$$\frac{\text{energy produced} - (\text{energy in added fuel} + \text{energy import})}{0.97 \times (\text{energy in the waste} + \text{energy in added fuel})}$$

equivalency factor electricity production x 2.6

equivalency factor heat exported x 1.1

(electricity + heating + hearting + water recycling/desalination)

0.97 = factor accounting for energy losses due to bottom ash + radiation

IBA = non-hazardous (or eco-hazardous ?) ... Fly ash = hazardous

Source : CEWEP

(100,000 tonnes = 7MW, 500-600 kWh/tonne, 1 kWh of power = 2.6-4.0 kWh heat)

(1 tonne of food waste = 0.33 MW)

Climate Change Impacts

EU emission targets = 20% by 2020, Coalition = 30%

Based on 1,000 kg of waste

Landfill :

60 kg CH_4 (50% captured and 50% released), 21 x global warming potential = 630 kg

Fossil carbon sequestration (mainly plastics) = 230 kg CO_2 = long term

Incineration :

310 kg CO_2 from non-biogenic wastes

CO_2 benefit by substitution of primary fuel : electrical power = 230 kg, used heat = 180

Overall net CO_2 impact = <u>minus</u> 100 kg

(Source : German municipal solid waste incinerators, 2007)

2010 EEA report : incineration = 0.1% of EU15 GHG, UK landfill= 30%

Current Proposals – mid 2010

Based on 'declared' tonnages and MW

	million tonnes	MW
Incinerators	**>7.0**	**>400**
Anaerobic Digestion	**>2.5**	**>50**
SRF	**>4.0**	**>200**
Pyrolysis/gasification	**>3.5**	**>200**
Biomass (exempt from WFD)	**>1.5**	**>150**
Mechanical Heat Treatment	**>2.0**	**30**
Co-firing	**>2.0**	**>1,000**
Wood chips (exempt from WFD)	**>17.0**	**>2,000**

To be treated with care : tonnages and MW not always quoted

Conclusions

- Integrated and sustainable resource management
  - sustainable consumption and production strategy
  - resource efficiency + energy efficiency
  - all wastes as resources - including fuel/energy and water : 'joined-up' thinking
  - 'carbon neutral' or 'carbon lean' ... 'Green New Deal'

- Protection of environment and health : scientific evidence and public awareness

- Increasing focus on residual carbon after prevention, reuse, recycling, composting
  - a hierarchy of energy from waste options based on efficiency, scale *et al*
  - incineration + co-incineration + MHT to divert waste from landfill

- 'Merchant' sites at various scales v. long-term contracts

- Capital finance + ROCs, FiTs, RHI ('Hot ROCs') + Landfill Tax + LATS

- Resource and Energy Recovery Parks : mapping demand and supply

- Leadership : national, local, commercial, investors + partnerships

MIPs and SSOs and Spatial Specificity (IPC + RSS v. MIU + local decision making)

NIMBY

NIMSBY

NOTE

ABH

LULU

NOOS

NIOBE

NOPE

NIABY

BANANA

(METHANE and LANDFILL)

NIMEY

NIMTOO

RUNGA

YIMBY

Incentivising Community Buy-In

- Potential use of community ownership structures for waste management facilities
- Community investment groups
- LAs to sell electricity not produced in association with heat
- Remove volume limits on exemption for small suppliers and between sites
- Community fund model to deliver planning gain
- Heat mapping to co-locate heat with demand
- District heating for all new-build
- Finance for more district heating networks
- Security of demand for district heating networks
- Better design of waste facilities
- Standardised review process for waste infrastructure development

(Source : APSRG (2010) 'Waste Management Infrastructure : Incentivising Community Buy-In')

- Section 106 agreements, Community Infrastructure Levy
- Discounted energy and tariffs for households /commerce/amenities, equity participation
- Coalition : community ownership of renewables + keeping additional business rates

Thank You

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