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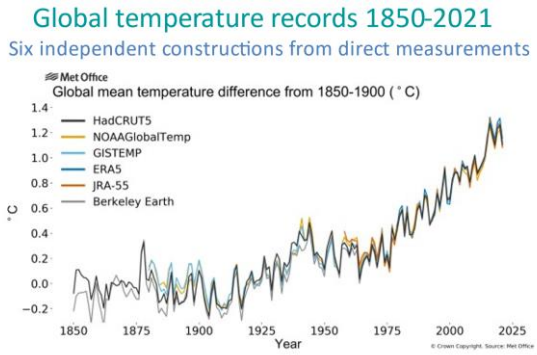
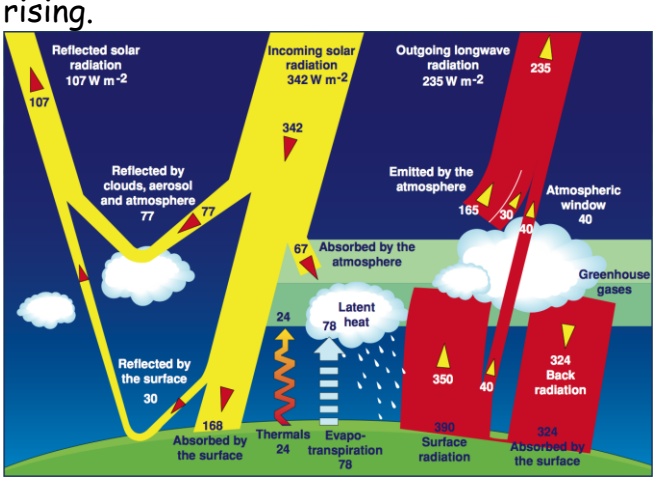
The Science behind Climate Change by Professor Joanna Haigh, CBE 26th April 2022

Before her recent retirement, Professor Joanna Haigh was co-Director of the Grantham Institute - Climate Change and the Environment at Imperial College London and was previously Head of the Department of Physics. She has been a Lead Author for the UN Intergovernmental Panel on Climate Change, IPCC, and shares a Nobel Peace Prize with several hundred others for that work. With these credentials, Professor Haigh gave a masterclass in the science behind climate change, based on observation and modelling.

She explained that the world is warming at a rate faster than has ever been observed in the past. Six independent studies of the temperature change over the last 170 years show a high correlation in the increase in temperature of just over 1 deg C from pre-industrial times.



This is due to the earth energy budget whereby the greenhouse gases trap the solar radiation and less is reflected back into space. Whereas oxygen and nitrogen have little effect on the infrared radiation, water vapour [clouds] and CO_2 are heated up by the infrared radiation with the result that half is radiated out to space but half is radiated back to earth causing an imbalance in the Earth's energy budget. This imbalance impacts on temperature, sea level, ice cover and weather. As of Spring 2022, the CO_2 in the atmosphere is still rising.



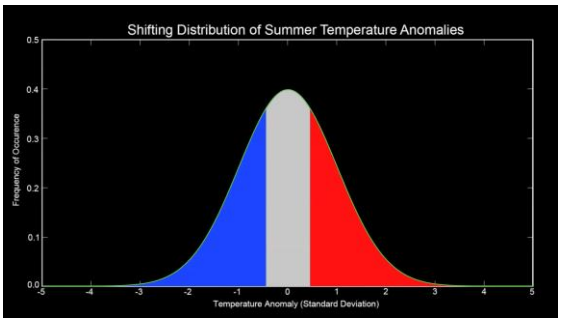
Earth's Energy Budget

A change in any stream will affect surface temperature

Computer modelling of the weather has to consider a 3D grid of the atmosphere with step changes in time. Complications arise with the scale of the grid, the behaviour of cloud/weather systems and initialisation data to start the model sequencing. Climate modelling, rather than weather modelling, predicts typical seasonal over an extended period.

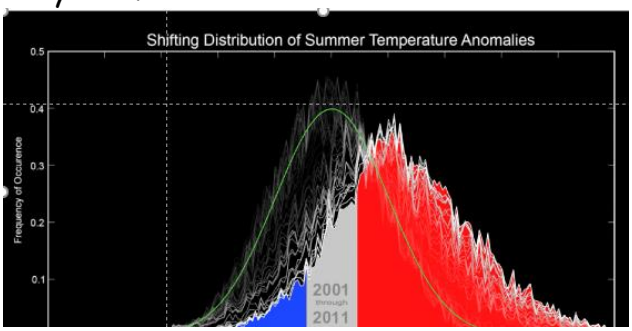
The rate of warming has increased 10 fold since the industrial revolution. It took 5000 years for the earth to warm 5°C after the last ice age, but only 100 years to rise a further 1°C. In the last century, this has

led to reduction of 40% in the Artic summer sea ice and a rise in the sea level of 0.2m. Without human factors, the simulation modelling shows that natural events themselves would remain fairly constant.



Summer Temperature Distribution 1950-60

Taking the natural distribution of summer temperatures anomalies in the northern hemisphere since 1950, it can be shown to skew to more severe events over the next 50 years.



Summer Temperature Distribution2001-15

Whilst the principal cause of temperature rise in the last 200 years was due to greenhouse gases, looking to the future, we need to consider not only the CO_2 concentrations but also radiative forcing factors.

In looking to predict future climate behaviour, modellers need to consider different radiative forcing factors as well as CO_2 concentrations in their models. This gives a range of outcomes, depending on whether optimistic or pessimistic assumptions are adopted. Relative to 1850, surface temperature rises could optimistically be kept to less than 2°C but without any mitigation the surface temperature could rise to nearer 5°C. The equivalent sea level rise with these temperatures would be 0.5m and 1.0m respectively. A 1.0m rise in sea level would mean that 3.6 million people in the UK would be subject to annual coastal flooding.

The increased temperature rise prediction by 2100 range from a further 1°C to over 4°C. This will cause a further sea level of between 0.3m and 0.6m impacting on over 300 million people.

Global temperature rise is proportional to total accumulated CO_2 emissions. To constrain global temperature rise below any particular value will require net greenhouse gas emissions to stop by some date. The greater the current emissions rise the sooner it needs to stop.

With agriculture and cement production, it is not possible to eradicate all GHCs production so the concept of Net Zero means that GHGs need to be removed from the atmosphere at the same rate as they are added. Net zero GHGs implies removal of carbon dioxide with 'negative emissions', either naturally with trees or technically with carbon capture and storage.

This leads to principles of carbon offsetting and carbon pricing, both of which could help to shift funds and make many Greenhouse Gas Reduction pathways economically viable.

Whilst there were pledges and commitments at COP26, there is still a long way to go. Given the unevenness to the COP26 commitments, there is a range of predictions of the temperature rise depending on the GHG emissions that are achieved. Taking the emission reductions pledged globally for 2030, the projected temperature in 2100 range from 1.5°C to 2.5°C. The ambition is that the emissions should have reduced to allow the lower end of the range.

Norman Train

Away-day Summer Dinner at Bicester on 28th June.

The summer dinner was a black tie event, where 37 members and their guests, including 6 past presidents, came together. The dinner also allowed us to celebrate the retirement of our long serving honorary secretary, John Beck with John and Frances being our guests of honour.

The dinner was as Bicester Hotel Golf and Spa, which is set in middle of the grounds of the golf course. With an outside drinks reception and our own private dining room, we were pleased to see many for whom this was the first event they had attended since the lockdowns.

The balmy evening commenced with a bubbly reception in the quad next to our own dining room. After the lockdowns there was great energy and excitement with old friends meeting up and much talking, to the point that the outside drinks reception over ran. And boy did we party; chatter was the feature of the whole evening in that there was enough room to circulated between the sprigs. The evening did not finally finish until 11.30 pm, which was fine since everyone was staying over with only a short saunter to their bedrooms.

A clandestine collection had been organised for a presentation to John and thank you to all of you who contributed to the £708 that was collected.

After the three-course meal and over coffee and chocolates, the President thanked John for all his work for the British Section over the last 21 years. He shared messages from Past Presidents who could not attend the dinner, going back to John's first President, Sidney Lessen, in 2001. He pointed out that John had served many Presidents, but the standout one with whom John found that he had a natural affinity and was always in tune was the 2011 President; Frances Beck's husband.

Lester Sonden had organised an etched decanter and presented this to John along with a couple of bottles of port. In the recognition of all the support that Frances had given John over the decades, she was presented with a planter of lavender decorated with butterflies.

Etched words on the glass decanter

John and Frances have asked that they can use the remaining funds towards a garden water feature for their new home.

On the morning after the dinner, some took advantage of the spa facilities in the hotel and others went on the visit to Elmsbrook to the north of Bicester, the only ecological new town in Britain.

Visit to Elmsbrook Eco-Town 29th June '22

A party of IESF members took advantage of an opportunity to visit Elmsbrook, a new 393 home development.

This is the first phase of a new eco-town that will eventually provide 6,000 homes and associated infrastructure. It is the only development to be built to the original high sustainability standards outlined in the UK's official government Eco Towns Planning Policy Statement (PPS) 2009, which was superseded in 2015. Constantly evolving techniques are being used to maximise energy efficiency which is

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exported back. Instead of a boiler in every home, heating and hot water comes from a Combined Heat and Power district heating system, currently gas-fired. The system generates electricity to the grid. In 2017/18 Elmsbrook exported 276,291 KWh more electricity than it imported. The heat-waste by-product is used to provide heating and hot water to all homes via a network of pipes. Individual properties have energy-efficient heat recovery ventilation to capture and re-use escaping heat.

Each home and business will have solar photovoltaic panels averaging 34m^2 per property, high insulation levels, triple glazed windows and doors. A timber-frame SIP's panelised system was used instead of traditional construction, which achieved increased air tightness and energy efficiency. As a result, residents used 28% less electricity than the Bicester average, saving 1189 KWh of electricity during the year. Homes are future proofed against climate change designed to prevent overheating based on 2050 weather predictions. Rainwater harvesting aims to reduce water consumption from 150 litres to 80 litres per person per day.

It is a testament to the numerous measures employed that Elmsbrook households had an average carbon footprint of 120kg this year, 95% lower than the national average (2447kg).

Thetownsquare.co.uk

The adjacent Bicester Eco Business Centre provides workspaces for small businesses and co-working spaces in one location. It is the first UK non-domestic building to achieve Passivhaus Plus standard, providing a high level of occupant comfort using very little energy for heating and cooling, a design protocol that combines high levels of insulation with exceptional air-tightness. The building generates as much energy as it consumes.

This glance at current best practice and a glimpse into a sustainable future proved a stimulating technical visit.

John Beck

Engineering Collaboration in the Delivery of the Elizabeth Line. Lecture by John Crosfield at the RAF Club, 18th October '22.

Our new member John Crosfield has had a long engineering career. His most testing and exciting project was his role over the

last seven years as head of technical assurance for the Elizabeth Line, formerly known as Crossrail. It was renamed the Elizabeth line in recognition of Queen Elizabeth's Platinum Jubilee.

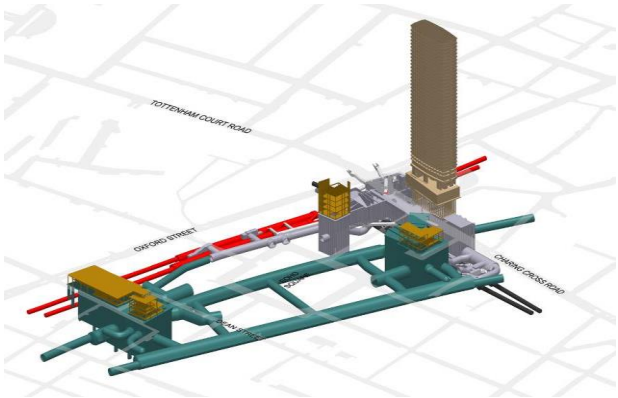
Crossrail is a high capacity Metro running from Reading and Heathrow in the West to Shenfield and Abbey Wood in the East, with 24 trains per hour in each direction in the central section between Paddington and Whitechapel. It will increase London's railway capacity by 10%—the largest increase since World War Two. Its trains have nine coaches of similar size to those of the London Overground, with power supplied at 25kV from overhead lines. The running tunnels are 6m internal diameter, much larger than the 3.81m of the Victoria Line or 4.35m of the Jubilee Line Extension, but less than the 7.2m of Thames Tideway or 7.15m of the Channel Tunnel Rail Link. At the peak of construction, Crossrail was the largest infrastructure project in Europe.

Safety is a core project value. All workers have the right to go home unharmed. Despite reviews of all critical activities, there was one fatality during construction.

The work was sub-divided into many contracts including four contracts for bored tunnels, ten for stations, one for trains, and two for depots. Trains are maintained at a new depot at Old Oak Common. Surface works included upgrades at 28 stations and 66 km of track, and two major structures.

Central section stations

Eight tunnel boring machines were used to bore the 42 km of running tunnels, then dismantled and brought out in pieces at the ends of their drives. Tunnels run at up to 40m below ground level. The longest bored tunnel drive was 8.3km from Liverpool Street to Farringdon. A computer simulated fly through showed the complexity of existing deep foundations that had to be avoided in the central section under London.



Tottenham Court Road – TBM interface close to sensitive structures

Sprayed Concrete Lining was extensively used to cater for variations in shape and diameter of 12km of tunnels and cross passages as well as a 17m high cavern at Stepney Green where running tunnels broke through in December 2015. Extensive compensation grouting was used to limit ground settlements, which themselves were less than predicted. For a section of 800m just west of Tottenham Court Road, settlements of up to 12mm were predicted but actual settlements were between 2mm and 6mm. Damage to existing buildings was negligible. Spoil from the tunnels was transported by river to Wallasea Island where it was used to create 620 hectares of marsh, wetlands and lagoons.

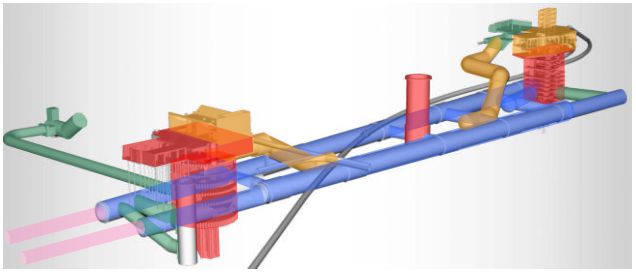
Five central stations were constructed using Sprayed Concrete Lining: Bond Street, Tottenham Court Road, Farringdon, Liverpool Street and Whitechapel. Stations at Paddington, Canary Wharf and Woolwich were built as boxes with deep diaphragm walls, propped at the top then dug out in top down construction.

At Paddington, the Elizabeth Line runs about 20m below street level under Eastbourne Terrace and the former cab road. Construction of the 255m long station box used 32,600 tonnes of concrete, 16,000 tonnes of steel, 166 reinforced concrete diaphragm wall panels, and 51 steel and concrete plunge columns. A glass roof with cloud motifs allows natural light into the Elizabeth line concourse.

Design Concept at Paddington, seen from the west

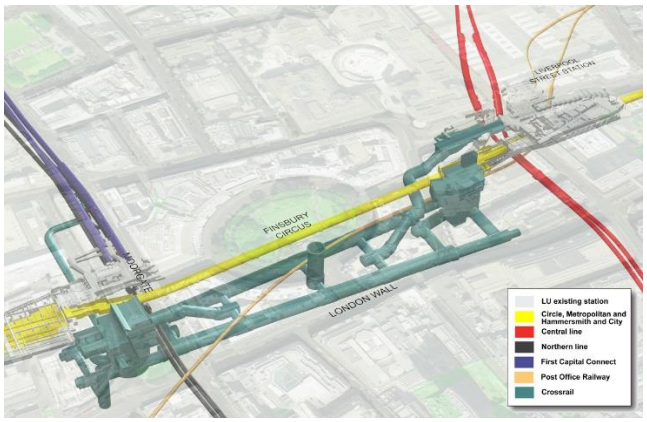
Sale of surplus land and property contributed £500 million to project funding.

There were 23 interfacing contracts for fit-out of the tunnels including platform screen doors, signalling, Overhead Line electrification, tunnel lighting, radio systems, communications and controls, fire mains, power cables, track and drainage. A full scale mock-up of a below ground station platform was built at Leighton Buzzard to show how everything had to fit together.



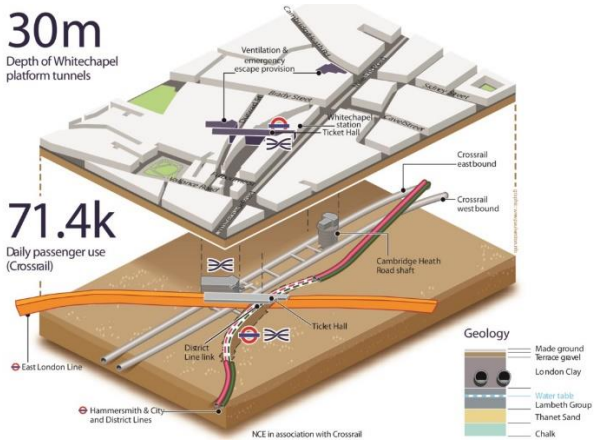
Tunnelled station strategy at Liverpool Street

The presentation included views from a 3D computer model showing sequences of construction and interfaces between new and existing railway structures at Paddington, Tottenham Court Road, Farringdon, Liverpool Street and Whitechapel, including the need to avoid damage to the Fleet Sewer, Post Office railway, running tunnels for the Central line, utilities, and other sensitive structures.



Interfaces with other rail lines at Liverpool Street

At Whitechapel, construction works were very congested. Some residents had to be rehoused during construction, and a temporary ticket hall used while the permanent one was being refurbished. Despite works above and below, the District and Hammersmith and City line trains were kept running except for some possessions at weekends.



Schematic of Crossrail, East London Line, and District Hammersmith & City lines at Whitechapel

The line opened in May 2022 as three separate railways: Maidenhead and Heathrow to Paddington, Paddington to Abbey Wood, and Liverpool Street to Shenfield, each on a different signalling system. Bond Street station opened on 24th October. The full line is now due to open in May 2023 with trains running from Shenfield and Abbey Wood to Heathrow and Reading. Opening was delayed by 3½ years of extended dynamic testing and commissioning led by Crossrail's latest chief executive, Mark Wild. The overall project cost increased from £15 billion estimated in 2010 to £18.75 billion today, Progress up to 2018 had been overstated and all systems had to be commissioned to work together—no mean feat!

The presentation was followed by a lively question and answer session, and a hearty vote of thanks from Graham Owens.

Peter Blair-Fish

"Piccadilly Line Upgrade - Challenges and Net Zero Carbon" National Liberal Club 17th November '22

New IESF member Ashraff Cader, a Fellow of the ICE, qualified as a Civil Engineer over 20 years ago, after which he spent time in Japan as an intern on the Japanese Railway's Ginza Line extension. For the last eleven years he has been with Transport for London, and is the lead Civil Engineer for TfL's Deep Tube Upgrade Programme (DTUP), where the current project is the Piccadilly Line Upgrade (at the time of this lecture, Ashraff had only recently returned from Sharm El Sheikh, where he had been playing a part in detailed discussions on reducing the Carbon impact of transport operations at the COP-27 Summit).

The Piccadilly Line Upgrade project will not only see 94 new trains introduced in about five years' time, and improved signalling to allow a more frequent service, but will also see a wide range of innovations targeted at achieving major reductions in the carbon footprint of the upgraded line. Ashraff himself has been actively engaged in the critical thinking necessary in order to define and achieve many of these savings - something of which he is rightly proud. The new rolling stock, which will replace the existing fleet of trains that were introduced in the 1970s, will introduce a new innovative train format with nine coaches rather than six, and with walk-through access for the full length of the train. Each train will have five 'motor cars, each with two 4-wheel bogies, between which will be four intermediate cars with no wheels, each supported by flexible supporting joints from the two adjoining cars. This design makes the train more flexible, to cope with bends in the tunnels, and the trains will be lighter in weight and have more efficient power systems, working at a higher DC voltage and with regenerative braking.

Siemens designed Piccadilly trains

Lighting will incorporate LED technology and cooling will be provided. At the same time, a great deal of engineering innovation has involved the infrastructure around the track, as well as improvements to the

ventilation of the tunnels. A surprising fact that Ashraff revealed was that the temperature of the London Clay through which the tunnels pass, which was a steady 14 deg C in 1900, had increased to 21deg C by 1960, and was now as high as 30deg C. There has always been a problem around keeping the passenger space cool enough in Summer, and simply adding air conditioning to the trains was not enough, as the heat taken out of the passenger space only made the tunnels warmer. So a radical solution has been to drive more vertical ventilation shafts, with controlled air flow, to take the excess heat up to ground level. Virtually every aspect of the Piccadilly Line infrastructure has been carefully examined, not just to ensure safety of the new trains in terms of their 'kinematic envelope', but also to look for savings - both in cost terms, and in carbon footprint - wherever possible. A key tool in the design process was to employ a train-mounted scanning system to survey the entire line digitally, allowing every aspect of the track and its surroundings to be accurately recorded - use of a train-mounted scanning system saved over £2.5 million against alternative methods.

Two infrastructure innovations that had provided Ashraff with much satisfaction were, firstly a change to the use of Aluminium conductors in the Power cables supplying power to the track and, secondly, the use of novel GRP posts for supporting power and signalling cables alongside the track. The Aluminium-cored power cables are lighter in weight than their copper-cored equivalents, albeit a little less easy to handle during installation, but they save £34 per metre (52%) in cost. In the case of cable support posts, where the existing concrete posts have needed to be replaced, the use of a novel design of GRP post, with a much simpler ('screw pile') method of fixing them into the ground, has eliminated a considerable environmental cost in the energy needed to make the concrete for new posts, in addition to which the GRP posts are much easier and quicker to install.

As a final comment, Ashraff mentioned that at every design-orientated meeting for the Piccadilly Line Project, there was a 'Carbon Moment' item on the agenda to ensure discussion of carbon reduction methods and to brain-storm what more could be done. Ashraff concluded his talk by displaying the 'Climate Clock' showing global warming. Copy the website below into your computer to see the world's march to the 1.5 C warming limit in real time. https://theconversation.com/climate-clock-reset-shows-the-world-is-one-year-closer-to-1-5-c-warming-threshold-169122

Afterwards it was no surprise that a wide range of questions followed the lecture before Ashraff was warmly thanked by the President.

Chris Lumb

IESF Voyage to Northern Island 16th – 22nd May '23

The Spring Voyage, being organised by our incoming president, Lester Sonden, is to Northern Ireland. Based in Belfast, we will see some of the Province's major tourist attractions including the Giant's Causeway and the innovative Titanic Exhibition in the new Titanic Quarter of Belfast.

Our thanks are due to those who have contributed to this newsletter. The editor welcomes contributions on matters that relate to the objectives of the Société. Email:paulgerrard24@gmail.com