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An unplanned adventure in Fire Science, Engineering, Testing & Regulation by Prof Luke Bisby

It is not often that an IESF technical lecture starts with a picture of a slice of cheese; to be precise Swiss Emmental cheese. Prof Bisby began his lecture by stating that unrelated consequences can have a profound effect on the final product. In Switzerland when Emmental was first made, the authorities dictated that there would be a tax on each round of cheese produced. Hence the cheese makers endeavoured to produce the largest rounds possible which, due to this size, produced the famous uniquely sized bubbles / holes in the cheese. Change the size of the round and the size and number of holes in the Emmental also changes.

Prof Bisby quoted the psychologist, James Reason who said that Societies put production before protection, that is they react in the aftermath of disasters not before them. As a consequence, Prof Reason said " Every society gets the disasters it deserves" There is no kudos in anticipating disasters!

In a similar analogy, fire testing of structures has been based on the time it takes for a loaded column to collapse in a fire. This was first tested in 1903 in a large fire box in Regents Park and tabulated in a graph in the American design codes in 1918. This form of test was used by the designer to state that a particular structure had a 2-hr, 3-hr, or 4-hr fire resistance. It did not take any account of the interrelationship between the structural elements in their fire resistance.

This is what we call 'Fire Resistance'
Fire Resistance = X hours

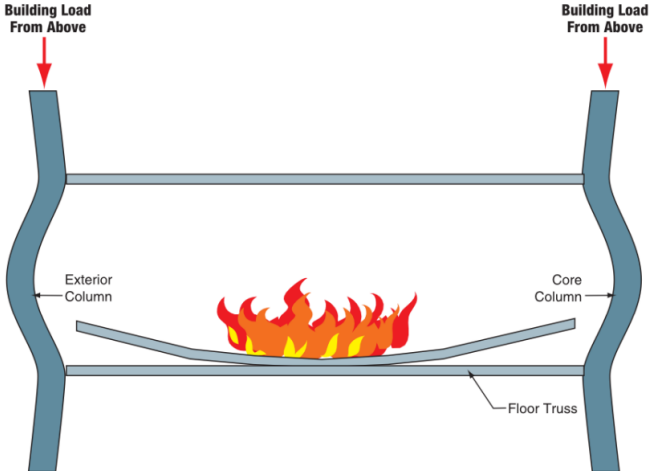
In Sept 2001, Prof Bisby was testing the fire resistance of fibreglass wrapped columns for his PhD project using this standard testing method when the Twin Towers were attacked. He, like the rest of us, watched in horror as the two towers collapsed in less than two hours after the impact. How could this happen when the fire resistance of the structure was above the 3-hr. design criteria of the American codes?

The design of the Twin Towers was based on a structural central core , carrying 60% of the load, surrounded by a 60 ft (18m) open floor plan to the external columns. It has been shown that the external damage was not critical in the towers' collapse. What is believed to have occurred is that the external columns collapsed due to buckling as

predicted by Euler's Column Formula, $P = \frac{\pi^2 EI}{L^2}$ where L is the length of the column. Remove one or two floors and the length of the free column doubles or triples in length. As a consequence, its load bearing capacity reduces to 1/4 for one floor removed and to 1/9 for two floors. Fire resistance of the column is irrelevant when its structural strength is so drastically reduced.

The World Trade Center Twin Towers Sept 11 2001

But why did the floors separate from the columns? There are two theories; the 60 ft long floor trusses expanded due to the heat of the fire and pushed the external columns out, or the floor trusses bowed due to the heat and separated from the columns. Both of which would result in the columns moving out of their vertical plan, effectively removing the columns horizontal restraint and hence decreasing the columns load carrying capacity.



Free column length doubles with one floor removed

Have the design codes changed because of 9/11? Obviously, yes but by what criteria? The American codes already had an extraordinary events factor, A_K , which requires the designer to include for an undefined "Event" and its frequency. The designer must decide what this "Event" is and allow for it. Quite a daunting task! In the WTC Building Performance Study, the question of whether building codes should be changed to make the building more resistant to such aerial attacks was explored. It concluded that depending on the size of the aircraft, it may not be feasible to develop design provisions to resist the effects of aircraft impacts, and the ensuing fires, without collapse. In addition, the cost of construction might be so large as to make this type of design infeasible.

This led Prof Bisby back to James Reason's often quoted "Every society gets the disasters it deserves". He concluded by saying that designers should rely on less mindless testing and concentrate on the thought process of potential failures.

Spring Voyage to Paris

Forty four members and partners assembled at St Pancras International Station to take the Eurostar train to Paris. A further eight joined us at the Paris hotel. The journey from Gare du Nord to the hotel was by coach giving us all a taster of the heavy traffic that we would experience in Paris when travelling by coach.

After a glass or two of champagne and a selection of hor's d'oeuvres in the hotel, the group boarded the coach again for a trip to Montmartre and the Basilica of Sacre Coeur. The basilica, which overlooks the entire city of Paris from its location 200 metres above the Seine, was proposed after the 1870 defeat of France in the Franco-Prussian war. Completed in 1914, the basilica was not formally consecrated until 1919.

Steps leading up to Sacre Coeur

The first of our splendid Voyage meals was taken in Montmartre, then returning to the hotel by the traffic-free Metro.

Friday morning 24th May
Conference Programme

In my 10 years membership of IESF, I have heard many lectures on a wide range of technical subjects, all well delivered and very interesting. However, without doubt the five presentations that comprised our morning conference were the best that I have ever heard; I feel privileged to have been there.

Notre Dame Cathedral

The first and keynote address was by Phillippe Villeneuve, the Chief Architect of France's historic monuments, who took charge of the magnificent restoration of Notre Dame Cathedral, following its catastrophic fire on 15th April, 2019.

Phillippe Villeneuve showing the internal devastation

He has a charming, self-deprecating and humorous manner. However, beneath this modest exterior, he is clearly an extremely efficient manager, who gets things done effectively and quickly. Just four days after the fire, the site was covered by a waterproof awning, enabling the challenging task of stabilising the structure to begin. What followed was five years of detailed and excellent work to rebuild the structure, clean what was left and employ an army of conservators to restore every aspect of this magnificent building to its former glory, at a

total cost of over 800 million Euros, all raised by private donations.

It is not possible to do justice to the detail of what we heard, but two of Phillippe's remarks give an insight into his motivation and ability. "At least the fire gave us an opportunity to restore things properly! I have worshipped at Notre Dame since a teenager, inspired equally by its music and architecture; I find these aspects of spirituality complement each other and inspired me to do what was necessary."

Underground Metro Station

After coffee, the second presentation was by Michel Pré, a leading consultant in SETEC. As the rail network round Paris is expanded to improve the economy of the surrounding areas, the decision was made to position the major new RER station at La Défense underneath the existing iconic CNIT conference building, without interfering in any way with the latter's operation. This first required the removal of 120 of the 250 pillars supporting the existing structure and the transfer of their loads to 60 new massive foundations with the construction of a new, 3 m thick slab. Once this was completed an underground 'cathedral' could be excavated to house the new station.

This extraordinary feat of foundation engineering was accomplished with residual displacements to the original CNIT structure of no more than two or three mms - an outstanding engineering achievement.

Terrell-Group-Projects

The third presentation was by Peter Terrell, founder and chairman of the Terrell Group, describing two amazing structures from this very innovative organisation's portfolio. The first was an extraordinary, gravity defying, 'pile of spaces' that build out of each other in a deliberately haphazard way. The visual effect is stunning and clearly involved some very innovative structural engineering. The innovation was firstly necessary to achieve plausible load paths through this disorder. It was also necessary to create sufficient order for the building to be constructable, albeit with considerable difficulty.

Peter Terrell explaining the design concept of the 'Pile of Space' building

The second project was a pair of organically shaped (think super maggots!) pair of hangars each 240 m. by 80 m. by 70 m. to house a new generation of rigid airships that will be launched in 2025. Constructed of steel with a fabric covering, the organic, curved shapes of both the hangars and their doors enabled substantial savings in both cost and embodied carbon, the latter an increasingly important criterion in this age of impending carbon breakdown.

Floating Offshore Structures

The fourth presentation was by Eichanan Safier, the founder and president of Safier Ingénierie, a structural and naval architecture international consultancy, specialising in offshore, usually floating, structures worldwide. His presentation began with an eloquent argument for the development of large scale, floating, structures to resolve the increasing shortage of land with the world's increasing population. He demonstrated the feasibility of the concept by illustrating the design of a major fish farm located offshore to improve the growing environment of an important source of protein. It would also be capable of supporting ultra large wind turbines. Such a concept addresses the two most pressing needs of a growing population - sustainable food supply and renewable energy.

Mont-Saint-Michel Tidal Restoration

The final presentation was by William Powles, our co-host for the Voyage. He was at one time manager of the major project to remove the causeway to Mont-Saint-Michel, the world-famous tidal island. The causeway, constructed in the 19th Century, had so obstructed the tides (despite their range of 15m) that silting was a major concern. A 20-year programme was initiated to restore the natural tidal flows and, over time, to remove the silt accretion. A barrier dam was initially constructed that increased river flow, by the use of rising sector gates and careful tidal management. Subsequentially, the causeway was replaced by a pedestrian bridge that did not impede the tidal flow. The revised scheme is clearly working; the silt is steadily disappearing and the amenity of the area is improving.

Graham Owens

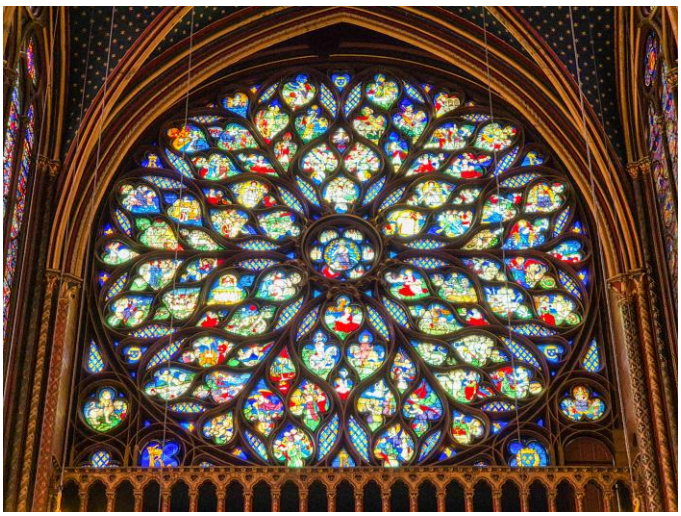
Visit to Notre Dame & Sainte Chapelle

Inspired by our morning lecture given by Philippe Villeneuve, Chief Architect Notre Dame Cathedral and refreshed by lunch, we all piled into the coach for what was supposed to be a brief coach trip to our next destination. However, Paris was getting ready for the Olympics and traffic journeys were affected. Suffice it to say we enjoyed the slow tour of Paris down the Champs-Elyees to the Place de Concorde where we saw the seated stands being erected for the Olympic Games. We then passed the building being renovated by the Peter Terrell Group and noted the very clever mirrored screening of the construction works and cabins.

Can you see the mirrored screening?

The benefit of the slow journey was that we were in perfect timing to watch the lowering of the cross on to the apse of Notre-Dame de Paris after a meticulous restoration by artistic ironworkers from Normandy, as

mentioned by Phillipe in our morning lecture. We enjoyed viewing a wall of storyboards alongside Notre Dame followed by an informative film summarising the restoration activities since the Notre Dame fire in 2019. We then queued again to see Sainte-Chapelle which is in the courtyard of the royal palace on the Île de la Cité (now part of a later administrative complex known as La Conciergerie). This was built around 1238 to house Louis IX's collection of relics of Christ, which included the crown of thorns, the Image of Edessa, and some thirty other items. It is a royal chapel in the Gothic style. The chapel was consecrated on 26 April 1248 and has two levels, equal in size, which had entirely different purposes. The upper level, where the sacred relics were kept, was reserved exclusively for the royal family and their guests. The lower level was used by the courtiers, servants, and soldiers of the palace. It was a very large structure, 36 metres (118 ft) long, 17 metres (56 ft) wide, and 42.5 metres (139 ft) high, ranking in size with the new Gothic cathedrals in France.



The restored Rose Window of Sainte Chapelle

The stained glass was removed and placed into safe storage during World War II. In 1945 a layer of external varnish had been applied to protect the glass from the dust and scratches of wartime bombing. In 2008, a more comprehensive seven-year programme of restoration began, costing some €10 million to clean and preserve all the stained glass, clean the facade stonework and conserve and repair some of the sculptures. Included in the restoration was an innovative thermoformed glass layer applied outside the stained-glass windows for added protection. The restoration of the flamboyant rose window on the west facade was completed in 2015 in time for the 800th anniversary of the birth of St. Louis.

Isobel Pollock-Hulf

Saturday 25th May '24
Château de Chantilly and Les Grandes Écuries

Arriving in good time after an early start, we had ample time to appreciate the Château's magnificent Renaissance-style architecture and setting in early morning sunshine.

The Château de Chantilly

The result of the reconstruction between 1875-1882 by Henri d'Orléans, Duc d'Aumale, of the original destroyed in the French Revolution, the château was built to house his vast collections of books, works of art and craftsmanship of all descriptions, some from 23 years' exile in England after the fall of his father, King Louis-Philippe. He bequeathed the entire collection to the French nation on condition that the paintings remain in their locations and no works loaned externally. From the grand entrance our self-guided tour included the chapel and galleries devoted to fine art, antiques, stained glass and all manner of antiques and collectables.

A special exhibition of Mediaeval Bestiary in the wood-panelled Reading Room showcased beautifully illustrated books from the duke's collection on various themes of animals: in the hunt; ferocious animals; animals in poetry and fables; used as emblems and illustrated in bibles and prayer books.

Further on were reception rooms - ornately gilded - with crystal chandeliers and decorative furniture and furnishings gathered by the duke from the royal family and royal chateaux. The Galerie de Cerfs, originally a music room, later a dining room, is furnished with hunting trophies and 17th C tapestries of hunting scenes and signs of the zodiac, the table set with elaborate place settings, candelabra, and glassware, for guests such as Empress Sisi, artists, and writers, including Zola and Dumas.

Further on the Galerie de Peinture displays some of the duke's art. He was a keen orientalist, as reflected by Algerian scenes originating from his time as an army general (1840-8).

Gilded furniture in a Reception Room

Further galleries showcase fans, extensive montages of portrait miniatures, antiques and gems. In the octagonal Tribune the walls are hung to illustrate the history of art, with works by Renaissance artists including Titian, Raphael, Fra Angelico, and Botticelli (readily recognisable from a portrait of a woman depicting "Autumn"); 17th & 18th C French and Dutch artists including Poussin and van Dyck; and works from 19th C France.

The Voyagers in front of the Chateau entrance

After lunch at a local restaurant it was time to visit the Grandes Écuries - the Grand Stables - complementary in style and scale to the château. Its magnificence was apparently accorded to the duke's belief that he would be resurrected as a horse; it also reflected the prevalent passion for hunting at that

time. After a 30-minute demonstration of dressage work (with French commentary) we were free to view the displays in the Living Museum of the Horse that explain, through all things equestrian the relationship between humans and horses from earliest times.
Our visit concluded with a train ride around gardens laid out by Le Nôtre; past the many water features, including waterfalls, a water recirculation system and still ponds acting as water mirrors; and various points of interest in the forest before returning to our hotel and the gala dinner. Diana Blair-Fish

Gala Dinner

The gala dinner was held in Brasserie Mollard, located opposite Saint-Lazare Station. Established in the second half of the nineteenth century the restaurant was transformed in 1895 into an icon to the Art Nouveau movement. It has been listed since 1987 in the Monument Historique classification.

Dinner in the Art Nouveau Restaurant

After a three-course meal our immediate Past President, Lester Sonden, ably assisted by his "French Interpreter" Norman Train, gave a resounding vote of thanks to our President Chris Foster and to William and Jocelyn Powles for their hard work in organising such a splendid voyage.

Sunday 26th May '24

Morning on Bateaux Mouche

An 0900hrs with bags packed and stored in reception, the short "hop" to the Wagram Metro began. After the 9 stops to Alma Marceau, the Voyageurs marched on to Ponte de l'Alma by 1000hrs for embarkation, avoiding the athletes competing in the Paris 10Km.
It was not raining but cloudy at 22 Celsius and the forecast was not inspiring.
The moorings were slipped by 1012hrs with room for all, including many other enthusiasts, on the upper deck. The Tannoy commentary began by telling us that we could navigate our location by the number of bridges we had sailed beneath. Most of us lost count after the first ten. Napoleon's main route to the sea 350 km away, is shallow, normally slow flowing and shares a similar colour to the Thames. However, in Paris the non-tidal Seine gains much from its handsome stone quays, many lined with trees.

As the boat headed upstream we passed the Grande Palace with its glass dome surmounted by a tricolour and then the Pont to the Dome of Les Invalides behind the Quai d'Orsay. The ornate Pont Alexandre III, built in 1900, had freshly gilded horses as Franco-Russian ornamentation. Apparently, Pont de la

Concorde was built from the stone of the Bastille. On the north bank we admired the massive scaffolding built for spectators of the Olympics, obscuring the Place de la Concorde. This was followed by the Jardin de Tuilleries and then the grand frontage of the Louvre. Pont Royale is a surprisingly clean cut bridge and was paid for by Louis XIV. The Pont du Carrousel built in 1939 is followed by the Pont des Arts, an iron footbridge built by Napoleon. The Ponte Neuf was the first to be built uncluttered with houses and is therefore the oldest. Then there were the splendid cranes supporting the works at Notre Dame de Paris which we had admired the day before. All eyes were glued to the spire of the Cathedral and the crowning ornamentation of M. Villeneuvre gleaming in the sun which had managed to break through the clouds. We passed under another five bridges onto the Isle de la Cite, which was originally a group of islands on which Paris was founded. Next we came to the smaller Isle St Louis reached by the Pont de la Tournelle and filled with what we were informed were 'des res' of the 17th Century. Under the oblique Pont de Sully and with Halle aux Vins on the Left Bank we reached the westward end of our tour while looking at the two decks of Pont d'Austerlitz where a railway crosses. We turned downstream on the northern side of the river passing the Hotel de Ville. The weather had changed for the better, the clouds were breaking up with ever growing areas of blue sky and Tony was still much in demand taking photographs of various Oriental couples.

The entrance to the Canal St Martin, giving access to the Port de Pleasance, was viewed and then we had a chance to travel under another six bridges and see the Conciergerie, which had been a prison, and other major landmarks again. At Pont de L'Alma we noticed the water level measurement station and were impressed by the five golden domes of the new Russian Orthodox church.

We could not help noticing the numbers of large river barges parked alongside the banks and quays. While many were restaurants and bars others looked remarkably like houseboats. On the Left Bank we reached Quai Branly with all its civil amenities, but everyone's eyes had turned to the splendid sight of Gustav Eiffel's Tower in full sunshine.

The Eiffel Tower from the River Seine

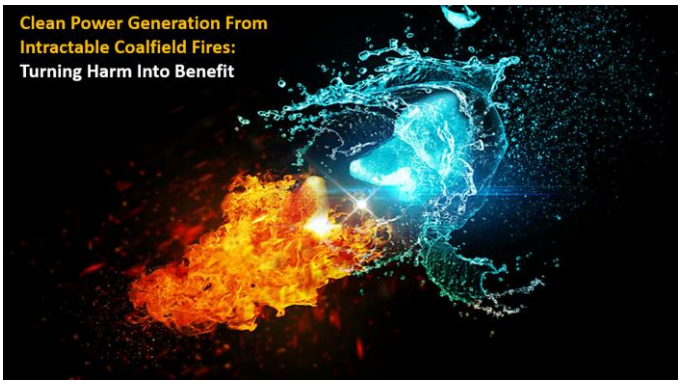
Just before the Pont de Biracaine, named for a battle fought by the Free French in 1942 and again on two levels with the trains on top, we turned again towards the three storey Tour Eiffel and returned to disembark. An hour of pleasant and informative sightseeing was over.

Back on the Quai de la Conferences the tail-end athletes were still finishing their Paris

10K. We promenaded on the Avenue Montaigne, past several notable Maisons de Couture to the Champs Elysees for lunch.
Report on Voyage ***Link*** Susan Shillito

Clean Power Generation from intractable Coalfield Fires by Prof José Torero

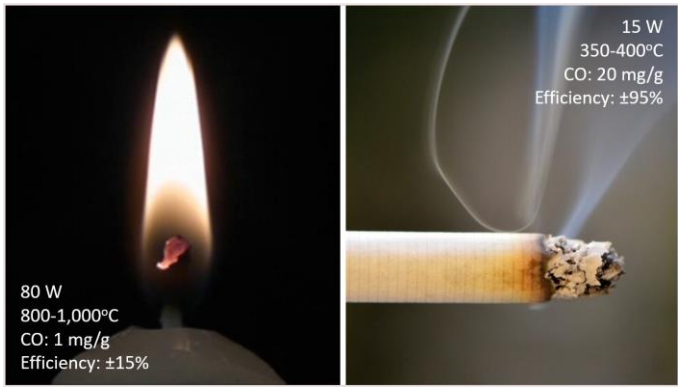
Professor José Torero challenged us to think of coal as a wasted source of clean energy. Coal: clean? The key to understanding this apparent oxymoron is waste: specifically its elimination, reduction and use.



Decisions on disposal of waste product have tended to be based on least cost of disposal, often resulting in incineration. Whilst incineration has become more efficient, the whole life cost and environmental consequences may still be overlooked. That must change, such that we recover everything of value which we have previously treated as waste, thereby transitioning to a circular economy. Energy recovery is part of the equation and may be regarded as 'clean' if it displaces the burning of fossil fuels. That doesn't necessarily rule out burning but the focus should be on whole life optimisation.

Professor Torero outlined the processes of smouldering and flaming combustion. Smouldering is the surface combustion of pyrolysis products derived from heating solid fuels, the essential precursor to flaming combustion for solid fuels such as paper, textiles and wood as is typical in many building fires. In buildings, the accumulation of heat energy and flammable gases from smouldering fires can lead to the sudden transition from smouldering to flame, and a rapid development of the fire. Flaming combustion is the burning of gases (in the presence of sufficient oxygen) produced by a higher rate of pyrolysis of solid fuels, evaporation of liquid fuels, or of naturally gaseous fuels.

If the source of oxygen is constricted, as within porous media such as the solid fuels just mentioned, smouldering can continue without flaming combustion. Smouldering is a more energy efficient process than flaming combustion. Although it has a much slower rate of release of heat energy, the energy released is used efficiently in pyrolising the fuel ahead of the advancing combustion wave, and high temperatures are achieved. The slow rate of diffusion of oxygen to the smouldering zone leads to an incomplete combustion process resulting in a high output of carbon monoxide per fuel - mass, in

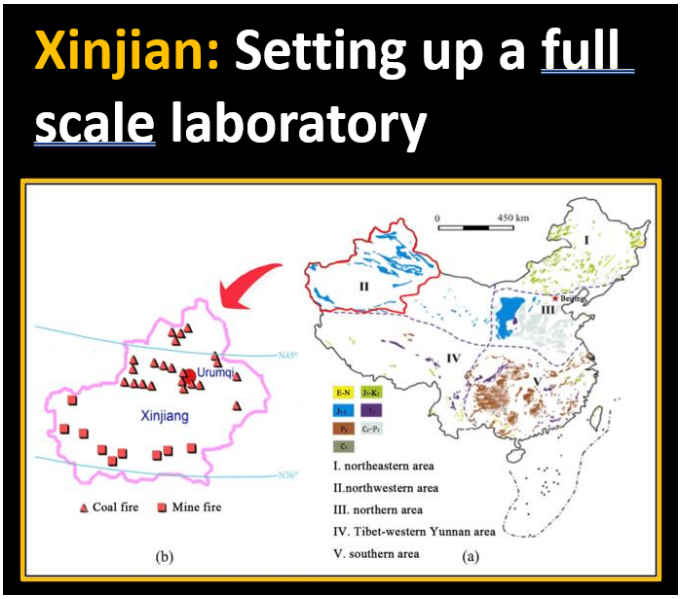


comparison to flaming combustion – including from cigarettes! There is a balance between the slow diffusion of oxygen into solid fuels of limited porosity, or fuel buried underground, and the slow transmission of heat energy. That contrasts with the high rate of energy transmission from flames by radiation (at the speed of light).

A perfect [I'm tempted to say 'perfectly formed'!] small-scale example of continuous smouldering is that of a toilet that processes human waste, recovering valuable nutrients. A similar process can be used for contaminated soil remediation leaving a clean matrix, landfill volume reduction, sludge treatment with phosphorus recovery, animal waste destruction, tyre destruction with oil recovery, and other applications.

Coal seam fires are of an entirely different scale. Each year about one billion tons of coal burn underground, about one eighth of total world consumption of coal. The energy emitted is roughly of the same order of magnitude as the electricity generated by nuclear or hydroelectric plants. They emit somewhere between 5% and 40% of fossil fuel emissions; emit several other pollutants including mercury; contaminate the atmosphere and underground water; damage the ecosystem; and lead to ground subsidence and social disruption. Some 2% to 5% of abandoned coal mines lead to subsurface fires. The oldest, 'Burning Mountain' at Mount Wingen in New South Wales, Australia, has been burning for about 6,000 years. They are very difficult to extinguish and until recently it was accepted that nothing could be done stop these fires.

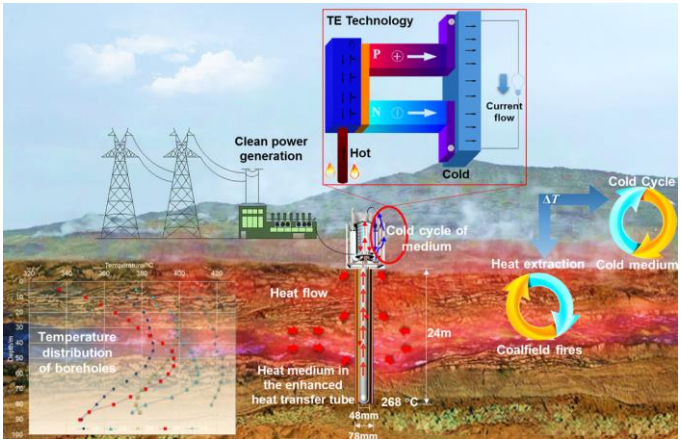
Professor Torero showed us some horrific images illustrating that close proximity to these fires might be hazardous to one's health, let alone carrying out any work on them. He described his own experiences – scary even to an audience seated comfortably in a lecture room in London – visiting sites of major coal seam fires in Australia and Xinjian Province in China for which he is contributing to the development of novel techniques for mitigating their effects.



The recovery of this otherwise waste energy underlies the solution. These subsurface fires are an enormous source of heat energy close to the surface at high temperature (around 1,200°C), and a source of combustible

gases. Any of this energy that can be harnessed can displace conventional use of fossil fuels such as for electricity generation. Extracting the energy progressively controls the fires, reducing and ultimately quenching them, eliminating the emissions of CO_2 and other pollutants, and remediating the ground.

The method involves sinking rows of boreholes into the burning coal seam, extracting heat with a circulating medium connected to a nearby power station. Successive rows of boreholes are drilled on an advancing front as, first, heat is extracted, and then water is used for cooling the ground, finally extinguishing the fire. Other methods are the underground gasification of the burning coal, using the extracted gas to generate electricity, and direct use of the heat as geothermal energy. There are numerous sites worldwide where these techniques could be applied including some in the UK.



The result is a win-win situation, mitigating the damaging effects of the fires whilst benefiting from the extraction of energy.

Philip Pascall

IESF Ski Trip 2025

The next IESF Ski Trip is to Cervinia in Italy at the beginning of March 2025. Cervinia is a high-altitude ski resort on the Italian side of the Matterhorn with great skiing and magnificent alpine scenery as well as snowshoeing, dogsledding and sleigh rides. The group is always looking for new members to join them. If you are interested, please contact Keith Hinde (khinde12@gmail.com)

New Members

Prof Luca Sportelli is a Chartered Engineer, Fellow of IMechE and the Design, Technology & Management Society as well as a Member of IE of Ireland. He is currently a Management Consultant, Lead Auditor, Technical Inspector and Welding Coordinator.

Hamish Douglas BEM is Chartered Engineer, Fellow of the ICE and IE of Ireland as well as a Member of the Bavarian Chamber of Civil Engineers. Before retiring was a Director of the International Division of STRABAG International (previously DYWIDAG International GmbH).

AMIS

Dixie Bayly widow of Bill Bayly, IESF President 2010

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