What is fusion?

Fusion is best known as the energy source of the stars. Under immense temperatures and pressures, stars like our sun force hydrogen nuclei to smash together and fuse into helium. This process releases a huge amount of energy that animates all life on Earth.

Why fusion?

Fusion is widely described as the holy grail of energy because it is clean, abundant and compact, in particular:

- The "ash" from fusing hydrogen is helium, the gas that we fill balloons with
- There are billions of years worth of fusion fuel on Earth, accessible in all water
- Half a pint of fusion fuel provides enough energy for an entire human lifetime

Why not hot fusion?

It's exceptionally difficult to mimic a star. We've been trying this approach for 70 years and have not yet passed energy breakeven, i.e. we still produce less energy from hot fusion reactions than we put in to heat the fuel to star like temperatures.

Most of the fusion resources continue to fund a massive 30 year international effort (ITER) to reach energy breakeven. ITER's initial budget of €5bn currently stands at the €25bn level and is rising. This experiment will likely not reach its full potential until the 2040s. We are not close to putting fusion energy onto the grid in this way and it's becoming increasingly clear that the realities of hot fusion machines do not match the dream.

Enter cold fusion

On March 23rd 1989 the world was stunned by the announcement of fusion at room temperature on a table top chemistry experiment - so called "cold fusion". This experiment involved conducting electricity through heavy water and into solid palladium metal (electrolysis) - something that a high school student could in principle do.

Despite the apparent simplicity, the experiments were difficult to reproduce and took 10 weeks to perform. Experimental replications were made over many months in reputable labs, e.g. Los Alamos and SRI international, but the failed high-profile replication attempts done over several days at MIT and Caltech won the day.

Cold fusion was an anathema to fusion physicists. Not only was it considered impossible to do fusion at low temperatures, but the expected fusion radiation would have killed anyone in the lab. Reasonable skepticism turned into dogmatic opposition where cold fusion scientists were ridiculed in public and accused of being incompetent, delusional and fraudulent.

Despite the words of Nobel prize winner and theoretical nuclear physicist, Julian Schwinger, who cautioned *"The circumstances of cold fusion are not those of hot fusion"*, the community had made up its mind. Mainstream journals quickly stopped accepting cold fusion papers for review and research drifted into the fringe.

Cold fusion 30 years on

Despite significant opposition and scarce resources over the years, a small group of scientists have continued to develop the basic science of cold fusion - now called Low Energy Nuclear Reactions (LENR). We now know:

- The effect is not limited to electrolysis
- The materials are not limited to palladium and heavy water
- The effect is due to the specifics of nano-scale structures found on (and inside of) solid materials
- We can prepare materials and conduct experiments to produce LENR frequently and with almost no time delay

In the past, significant effort was expended in convincing people of the reality of LENR. Today, programmes exist in all corners of the world: Japan, China, Russia, India and the USA (the UK being notably absent), big names such as Google and Bill Gates have entered the arena and the private LENR sector continues to grow, e.g.

- Leonardo Corporation / HydroFusion - 1997 / 2011, Florida USA / London UK
- Brillouin Energy - 2009, California, USA ($7.8M)
- Nichenergy - 2010, Milano, Italy
- Industrial Heat LLC - 2012, North Carolina, USA, ($32M from Woodford)
- Clean Planet - 2012, Tokyo, Japan

There is a new found respect for the subtleties of the material science that governs LENR and an increasing willingness to explore this area again - particularly when set against the backdrop of climate change.

Where do we go from here?

What's missing are experiments that are simultaneously:

- Reproducible
- Produce useful amounts of power
- Controllable

Finding that "sweet spot" has proved elusive, mainly because researchers have tended to specialise prematurely by focussing on one particular LENR approach. The diversity in experiments and materials suggests that what's driving LENR will only be uncovered by an effort to explore multiple approaches in parallel.

Alongside the technical research, there needs to be an effort to bridge the credibility gap that continues to exist between LENR and the mainstream. Trust needs to be built in both scientific and public realms in order to fully realise the potential for LENR as a clean, compact, mobile source of energy.

Trust is best built by working openly as the default. The continual challenge will be maintaining a healthy degree of openness while simultaneously building a thriving business. While openness won't be easy, we know that open patents are possible, open-source hardware can support successful businesses and the additional benefits are significant. In particular, we'll be able to bootstrap development by harnessing planetary-scale intelligence to refine ideas quickly, avoid repeating the mistakes of others and discover hidden fusion talent.