The Path to Commercial Fusion Energy

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Fusion energy is transitioning from a long-standing scientific ambition to a credible pathway for large-scale, low-carbon energy generation. This presentation examines how fusion is moving from experimental facilities to commercial power plants, and why its success is important for addressing climate change, public health, and global stability. Over the past five years the global landscape has expanded rapidly with more than 40 private fusion companies alongside major national and international programmes. This growth reflects a healthy balance of collaboration and competition focused on realising fusion's unique benefits: an abundant fuel supply, intrinsic safety, and reliable baseload power. In this context, fusion is a critical complement to renewables, enabling resilient net-zero energy systems.

This talk introduces the principles of fusion energy, outlining how fusion reactions work and summarising the confinement technologies currently in operation or under development. As more fusion machines demonstrate record-breaking performance in energy production and plasma duration, it has become clear that fusion is no longer limited by fundamental physics. Instead, the challenge has shifted to the integration of complex multi-physics systems into mature technologies that can be deployed at scale. Key technology enablers, such as high-temperature superconducting magnets, advanced diagnostics, materials and fuel cycle development, AI, and high-performance computing, will be discussed, with particular emphasis on the fuel cycle. Finally, the talk looks ahead outlining the major machines, pilot plants and power stations expected to come online and the exciting opportunities this highly multidisciplinary field offers to the next generations of scientists and engineers.