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Smaller & Sooner –Exploiting high magnetic fields from new superconductors for a more attractive fusion energy development path

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The recent industrial maturation of high-temperature, high-field superconductors opens up a faster and cheaper development path for fusion energy by enabling reactor-level performance at smaller scale. The current fusion energy development path, based on large volume moderate magnetic B field devices is proving to be slow and expensive. A development effort is underway on new superconductor magnet technology development, and accompanying plasma physics research at high-B, that will open up a viable and attractive path for fusion energy development. This path would feature smaller volume, fusion capable devices that could be built more quickly than low-to-moderate field designs based on conventional superconductors. Fusion's worldwide development could be accelerated by using several small, flexible devices rather than relying solely on a single, very large device. These would be used to obtain the acknowledged science and technology knowledge necessary for fusion energy beyond achievement of high fusion plasma gain. Such a scenario would also permit the testing of multiple confinement configurations while distributing technical and scientific risk among smaller devices. Higher field and small size also allows operation away from well-known operational limits for plasma pressure, density and current. The advantages of this path have been long recognized –earlier U.S. plans for burning plasma experiments [Compact Ignition Tokamak (CIT), Burning Plasma Experiment (BPX), Fusion Ignition Research Experiment (FIRE)] featured compact high-field designs, but these were necessarily pulsed due to the use of copper coils. Underpinning this new approach is the recent industrial maturity of high-temperature, high-field superconductor tapes that would offer a truly "game changing"opportunity for magnetic fusion when developed into large-scale coils. The superconductor tape form and higher operating temperatures also open up the possibility of demountable superconducting magnets in a fusion system, providing a modularity that vastly improves simplicity in the construction, maintenance, and upgrade of the coils and the internal nuclear engineering components required for fusion's development.

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