Status of US ITER Contributions

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Fusion Power Associates December 7, 2017





US ITER Hardware Scope Full Scope



ITER Project has Defined First-Plasma and Post-First-Plasma Hardware

US First Plasma SP-1 → CUS Post-First Plasma SP-2 →				
R&D and Design	Full Fabrication	Partial Fabrication	Completion of Fabrication	Full Fabrication
Completion for All Hardware	 Central Solenoid (in fabrication) Toroidal Field Conductor (completed in FY17) Steady State Electrical Network (completed in FY17) 	 Tokamak Cooling Wa (some delivered) Roughing Pumps Vacuum Auxiliary System Pellet Injection Ion Cyclotron Heating Electron Cyclotron Heating Diagnostics Instrumentation & Comparison 	ter System stem (some delivered) g eating ntrols	 Tokamak Exhaust Processing Disruption Mitigation

US Hardware Toroidal Field Conductor Completed

Strand was produced by Luvata Waterbury, Inc. in Waterbury, CT (above) and Oxford Superconducting Technologies in Carteret, NJ.

Cabling of the strand was performed by New England Wire Technologies in Lisbon, NH.



The conductor was jacketed and integrated at High Performance Magnetics in Tallahassee, FL and Criotec in Chivasso, Italy (above).

US Hardware Steady State Electrical Network Completed







The final shipments of power transformers were delivered in December 2016.

The final lots of reactive power compensators were shipped in September 2017.



US Hardware Central Solenoid Module Fabrication Progressing



Serial module fabrication is underway at General Atomics' 64,000 ft² Magnet Technologies Center. The facility includes 10 work stations.

US Hardware Central Solenoid Module Fabrication Progressing



Central Solenoid Winding of Module 4 (of 7) is Underway

Winding table in action at General Atomics. Photo: GA

Central Solenoid Module 1 Completed Turn Insulation



Turn insulation station in action at General Atomics. Photo: GA

Central Solenoid Structures and Assembly Tooling in Fabrication



US Hardware Tokamak Cooling Water System

Initial deliveries complete; piping fabrication underway

Final Design Review for First Plasma hardware was held in November 2017



Drain tanks fabricated in the US were the first nuclearcertified components delivered to the ITER site (September 2015). Pipe fabrication is underway at the Schulz Xtruded Products facility in Robinsonville, MS.

US Hardware Ion Cyclotron Transmission Lines

Ion Cyclotron Heating First Plasma hardware FDR September 18-19, 2017 Prototypes in fabrication and testing; production unit fabrication started

- 20 megawatts total power transfer to the plasma
- Up to 6 megawatts per line



US Hardware Electron Cyclotron Transmission Lines

Prototypes in fabrication and testing; contracts for manufacturing processes awarded

- 20 megawatt total power transfer to the plasma
- 1.2 megawatts per line



A laser-based wave guide inspection system was developed



Waveguide switch prototype

US Hardware Pellet Injection and Disruption Mitigation Systems

- Prototypes are in fabrication and testing; testing on current tokamaks continues
- Cryogenic pellet plasma fueling in development to perform at 300 m/s at 16 Hz



A shattered 7 mm neon pellet in DIII-D tokamak plasma



Shattered pellet injection components in a test stand at ORNL before installation on JET for further testing.

US Hardware Vacuum Auxiliary and Roughing Pumps System





The full-sized cryoviscous compressor prototype was tested at ORNL's Spallation Neutron Source Cryogenic Facility before shipment to ITER for further testing.

US Hardware Diagnostics

State of the art distributed plasma diagnostics have been in design, with prototypes in fabrication and testing



12/07/2017

US Hardware Tokamak Exhaust Processing

Tokamak Exhaust Processing PDR May 16-17, 2017

- High-throughput (240 Pa*m³/sec) tritium processing system is in design
- Palladium membrane separates hydrogen isotopes from methane-steam reforming reaction



High density of equipment in Tritium Building

Typical glovebox

US Industries, Universities and National Laboratories are Engaged

General Atomics, San Diego, CA Massachusetts Institute of Technology AREVA Federal Services, LLC, Charlotte, NC University of Texas at Austin Luvata Waterbury, Inc., Waterbury, CT University of Tennessee Precision Custom Components, York, PA Florida State University Oxford Superconducting Technology, Carteret, NJ University of Wisconsin at Madison Transfair, Sea Tac, WA University of California Los Angeles .edu High Performance Magnetics, Tallahassee, FL University of Michigan Schneider Electric, Palatine, IL University of California San Diego Robatel Technologies, Roanoke, VA Columbia University Petersen, Inc., Ogden, UT .com Washington State University Superbolt, Carnegie, PA Indiana University Hyundai Corporation, Houston, TX New England Wire Technologies, Lisbon, NH Oak Ridge National Laboratory .gov Princeton Plasma Physics Laboratory **Transproject,** Houston, TX Robatel Technologies LLC, Roanoke, VA Sandia National Laboratory Savannah River National Laboratory Hamill Manufacturing, Traford, PA Major Tool & Machine, Inc., Indianapolis, IN Los Alamos National Laboratory Lawrence Livermore National Laboratory Mega Industries, LLC, Gorham, ME **Dielectric Communications**, Raymond, ME Idaho National Laboratory Siemen's Industry, Inc., Wendall, NC Fermi National Laboratory Eaton Corporation, Cleveland, OH Argonne National Laboratory **G&G Steel**, Russellville, AL Lawrence Berkeley National Laboratory

Over 80% of Awards and Obligations Remain in the US

600+ contracts awarded to US industry and universities, and obligated to DOE national laboratories in 44 states

500+ direct jobs and 1100+ indirect jobs created or maintained per year.



DOE Deputy Secretary Approved First-Plasma Performance Baseline and Total Project Range on January 13, 2017

DOE-approved Package (Jan 2017)

First Plasma Project Baseline (CD-2/3):

- Total project cost (TPC): \$2.5B
- CD-4: December 2027

Total US ITER Project Range (CD-1R):

- Cost range: \$4.7B-\$6.5B
- CD-4: 2034-2038

driven by budgetary constraints—not technical

September 2034 – March 2038



US ITER has demonstrated consistent strong performance when resources are available

Partnership in ITER enables US participation in the study of burning plasmas

Sauthoff/Fusion Power Associates