Overview of Fusion Research Activities in China

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Direct-General, CNDA, MOST

Virtual Meeting, March 23, 2021 presented at 10th MFCW
Contents

01 Progress of ITER Implementation in China

02 Progress of Domestic R&D in Fusion Energy Research in China

03 Progress of Fusion Research International Cooperation in China
China’s In-Kind Contribution to the ITER Machine

Total: 269.565 kIUA

Activity completion: 71.24%

14 PAs and 4 amendments have been signed for magnets, blanket, power supply, diagnostic system etc.
CNDA PA Highlights

- Feeder ICF delivery
- Feeder CTBs assembly
- Feeder TF CFT FAT
- CC packing
- CC case laser welding
- CC winding
CNDA PA Highlights

Qualified Semi-Prototype FW (5 MW/m²)

Qualified Shield Block Prototype

Unique HHLT facility for ITER (10⁻¹⁰ Pa • m³/s)

PF5, PF6, and 1st CC supports delivered
CNDA PA Highlights-CC Delivery Ceremony

Ceremony for the Delivery of the First Batch of ITER CC Coils, September 22, 2020

Minister of Science and Technology, WANG Zhigang read out the Message.

Congratulatory Message from President XI Jinping, the People’s Republic of China

Vice Minister of MOST, HUANG Wei joined the on-line event.
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Domestic MCF R&D Program

Scope & Objectives

- Obtain ITER key technologies after its construction
- Effectively participate in research activities on the ITER device
- Promote basic fusion physical research and expand talent pool
- Assignments deployed to DEMO’s design and R&D
Domestic MCF Facilities in China

- Chengdu, SWIP, HL-2A/2M
- Wuhan, HUST, J-TEXT
- Hefei, ASIPP, EAST
- Hefei, USTC, KTX

China's domestic MCF facilities are distributed across various provinces and regions, including Beijing, Shanghai, Jiangsu, Zhejiang, Anhui, Hubei, Sichuan, Yunnan, Guangdong, Guangxi, Hainan, Heilongjiang, Jilin, Liaoning, Tianjin, Hebei, Shanxi, Inner Mongolia, Gansu, Qinghai, Ningxia, Shaanxi, Henan, Jiangsu, Shandong, Shanghai, Zhejiang, Jiangxi, and Tibet. Each region hosts specific facilities dedicated to the development and advancement of MCF technologies in China.
Research Institutes, Universities & Enterprises

- Southwestern Institute of Physics (SWIP)
- Institute of Plasma Physics, CAS (ASIPP)
- China Academy of Engineering Physics (CAEP)
- University of Science and Technology of China
- Huazhong University of Science and Technology
- Tsinghua University
- Peking University
- University of Science and Technology Beijing
- Sichuan University
- Beihang University
- Dalian University of Technology
- Harbin Institute of Technology
- Western Superconducting Technologies Co., Ltd
- Advanced Technology & Materials Co., Ltd (AT&M)
- Xiamen Honglu Tungsten Molybdenum Industry Co., Ltd
- …

Nearly 60 entities in China have contributed to MCF R&D since 2008.
Highlights on Domestic Fusion Activities

China Fusion Energy Conference (CFEC 2019) & Fusion Energy Activities Week

November, 2019
>1200 attendees

Highlights:
CFEC 2021
Hefei, China
A total budget of **5581 M RMB (678 M Euros)** has been enacted between 2008 and 2019, to support ITER procurement R&D, domestic facility upgrade/key technology development/experiment campaigns, exclusive CFETR activity and so on.
China's domestic MCF R&D program has funded four key areas over the past decade, up to a total of 160 research projects between 2008 and 2018. **The FY2019 budget plans to support 30 projects.**
Recent Progress and Highlights

EAST Tokamak, ASIPP, Hefei.

1) 101.2 s! The longest plasma charge duration.
2) A promising high–confinement regime for steady–state fusion (EAST grassy ELM regime)
3) A new criterion for ELM control based on multimode plasma response
4) Steady–state fast–ion confinement & Alfven Eigen modes instability
5) EAST has achieved >1 mins steady–state high–performance scenario in support of the CFETR 1GW scenario.
6) ITER equivalent high–power auxiliary heating and current driving capability.
7) International collaborators from more than 10 countries and 20 institutes contributed in more than 50% experiment proposals, while 4 international proposal weeks were scheduled in 2020 EAST campaign.
Recent Progress and Highlights

14:02, December 4th, 2020, HL-2M obtained its first plasma.
Roadmap towards Fusion Energy
- proposed by the Chinese fusion research community

Chinese Fusion (Demonstration) Prototype Power Plant

- **CFETR**
  - First Phase: Q=1~5; Steady, 200MW, 10dpa
  - Second Phase: Q>10; Steady, 1GW, 50dpa

- **ITER**
  - First Phase: Q=10; 400s, 500MW, D-T Burning Plasma Experiment
  - Second Phase: Q=5; 3000s, 350MW, Long Pulse Burning Plasma experiment

- **EAST**
  - Steady Advanced Divertor Configuration; Steady H-mode Plasma Experimental Research

- **HL-2M**
  - Advanced Divertor; Heating, Drive, Diagnosis in High Parameters

- **J-TEXT**
  - Disruption Control; Basic Plasma Research

Timeline:
- 2015
- 2020
- 2025
- 2030
- 2035
- 2040
- 2045
- 2050
- 2055
- 2060

**PFPP**
- 1GW, Grid-Connected Safety, Reliable, Efficient
CFETR: R&D Strategy

Advanced Diverter
Breeding blanket
Tritium loop system and radiation protection
HL-2 experiments and technology
EA ST experiments and technology
CN ITER PA
First wall and blanket materials
Other physical research: Heating, CD, Diagnostics etc.

Ministry of Science and Technology of the People’s Republic of China
CFETR Progress Updates

Concept design of CFETR (2011–2014, MCF R&D Program Funded Project)

Integration engineering design of CFETR (2017–2020, MCF R&D Program Funded Project)
- CFETR physics design and parameter optimization
- CFETR nuclear safety framework
- Overall integration of engineering design of CFETR
- Design of CFETR auxiliary systems
- CFETR database system
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Highlights between China and ITER

IC-24 June 20 2019
Cadarache, France

IC-25 November 20 2019
Cadarache, France

IC-26, June 18, 2020, Virtual Meeting

IC-27, November 18, 2020, Virtual Meeting
Highlights between China and ITER

MAC-27 May 22 2019
Cadarache, France

MAC-28 October 23 2019
Cadarache, France

MAC-29, May 18, 2020, Virtual Meeting

MAC-30, October 20, 2020, Virtual Meeting
Highlights in 2020/2021

Medical Supplies Donation for COVID-19

"United we shall overcome"
Donated by CNNC (CNPE-CNI23-SWIP)

ASIPP Donated 60000 Masks to IO
# Highlights between China and IEA

## China’s Participating in IEA-FPCC-TCPs

<table>
<thead>
<tr>
<th>No.</th>
<th>Project Description</th>
<th>Institution</th>
<th>Start Date</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Fusion Materials, FM-TCP</td>
<td>Southwestern Institute of Physics (SWIP)</td>
<td>Since 1998</td>
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<tr>
<td>2</td>
<td>Nuclear Technology of Fusion Reactors, NTFR-TCP</td>
<td>Institute of Nuclear Energy Safety Technology (INEST)</td>
<td>Since 2010</td>
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<tr>
<td>3</td>
<td>Environmental, Safety and Economic Aspects of Fusion Power, ESEFP-TCP</td>
<td>Institute of Nuclear Energy Safety Technology (INEST)</td>
<td>Since 2011</td>
</tr>
<tr>
<td>4</td>
<td>Co-operation on Tokamak Programmes, CTP-TCP</td>
<td>China International Nuclear Fusion Energy Program Execution Center</td>
<td>Since 2011</td>
</tr>
<tr>
<td>5</td>
<td>Spherical Tori, ST-TCP</td>
<td>Tsinghua University (THU)</td>
<td>Since 2020</td>
</tr>
<tr>
<td>6</td>
<td>Stellarator-Heliotron Concept, SH-TCP</td>
<td>Southwest Jiaotong University (SWJTU)</td>
<td>Since 2020</td>
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<tr>
<td>7</td>
<td>Reversed Field Pinches, RFP-TCP</td>
<td>University of Science and Technology of China (USTC)</td>
<td>Under Consideration</td>
</tr>
<tr>
<td>8</td>
<td>Plasma Wall Interaction, PWI-TCP</td>
<td>Institute of Plasma Physics, Chinese Academy of Science (ASIPPP)</td>
<td>Under Consideration</td>
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Highlights between China and IEA

IEA Academy
Today in the Lab-Tomorrow in Energy
October 8, 2020

IEA FPCC, February 24, 2021
Highlights between China and US

9th US-PRC Magnetic Fusion Collaboration Workshop
June 5-7, 2018 Xi’an, China
Highlights between China and EU

• Under the China-EU Joint Steering Committee on S&T Cooperation and R&D Cooperation in the Peaceful Uses of Nuclear Energy (PUNE), CN-EU cooperation has been on-going well for the past few years.

• Bilateral Meeting between MOST & F4E was held in September, 2017.

• TMP-1 working group meeting was held in Jan, 2018 in Chengdu, China.

• FU-7 was held in October, 2018 in India.
Highlights between China and EU

PF6 on board
March, 2020
**Highlights between China and France**

**SIFFER**
SIno-French Fusion Energy center (China and France)

**Key mission:**
1) Support to ITER Organization and partners.
2) Develop and validate key components and technologies of magnetic fusion devices (CFETR, DEMO).
3) Fusion science and experimental physics research.

**SIFFER BoD-7**
March 5, 2020, Beijing, China

**SIFFER GB-3**
December 16th, 2020, Beijing, China
Highlights between China, Japan and Korea

CJK-6 Trilateral meeting, 1-2, August, 2019, Seoul, Korea.

JCM-8, December 7-8, 2020, Xi’an, China

JWG-13, December 18, 2020, Beijing, China
THANKS!