Steady-state spheromaks for the pursuit of economical fusion power

Derek Sutherland
Co-founder and CEO

Mobile: +1(407)754-4511
Email: dsutherland@ctfusion.net
Problem

We need clean, safe, and reliable energy sources to displace those harmful to people and the environment.
Solution

*Fusion is a revolutionary energy solution, provided it is economically attractive.*
The CTFusion approach to economical fusion

• Simpler, compact fusion reactor design.

• More plasma current, fewer expensive superconducting coils.

• Uses breakthrough plasma current sustainment technology.
Enabling Technology

1. Use spheromak for a simpler, more compact fusion reactor.

2. Use Imposed-dynamo current drive (IDCD) for efficient sustainment of plasma current in stable spheromaks.

Both synergistic technologies enable economical fusion power.
Gen I Prototype

- IDCD has been demonstrated at 1/10 commercial scale in Gen I Prototype at University of Washington (UW).
Key actions for performing IDCD

1. Driving the plasma current near the plasma chamber wall

2. While imposing oscillating magnetic perturbations

Both actions must be performed simultaneously to sustain stable spheromak plasmas
Dynomak reactor vision

Key Reactor Vision Features

- Deuterium-Tritium (DT) fusion fuel
- Steady-state operation
- IDCD for plasma current sustainment
- Molten-salt (FLiBe) liquid blanket
- 1000 MW-electric design point
- $\approx 2,800/kW$ capital cost in 2016 USD
Competitive Advantage

• CTFusion uses a well-developed approach to fusion: deuterium-tritium (DT) magnetic fusion energy (MFE).

• CTFusion applies the breakthrough plasma sustainment technology of IDCD to DT MFE, allowing for the use of a spheromak.

• CTFusion’s approach to fusion power has low technical risk and maintains economic competitiveness.
CTFusion’s fusion approach is situated in a similar plasma regime as mainline MFE concepts, but has low reactor costs.

Figure paraphrased from Dr. Patrick McGrath’s 2016 ARPA-E ALPHA Meeting talk
Primary market segment: heat for electricity generation

**Product:** Low-cost fusion power cores

**Heat for electricity**
- Robust market
- Strong Demand
- Forecasted Growth
- Multi-B$ Industry
- No energy storage required
## Additional Market Segments

### Secondary Segment

<table>
<thead>
<tr>
<th>Neutrons for cleanup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited market</td>
</tr>
<tr>
<td>Potential Growth</td>
</tr>
<tr>
<td>Government Run</td>
</tr>
<tr>
<td>Regulatory challenges</td>
</tr>
<tr>
<td>Eliminates fission waste</td>
</tr>
</tbody>
</table>

### Tertiary Segment

<table>
<thead>
<tr>
<th>Deep-space propulsion</th>
</tr>
</thead>
<tbody>
<tr>
<td>New market</td>
</tr>
<tr>
<td>Potential Growth</td>
</tr>
<tr>
<td>Earth-Mars travel</td>
</tr>
<tr>
<td>Outer solar system travel</td>
</tr>
<tr>
<td>Interstellar travel</td>
</tr>
</tbody>
</table>
Research and development needs

• CTFusion must demonstrate plasma driver technology in an optimized reactor geometry.

• CTFusion must demonstrate high temperature (> 10,000,000 °C) plasma sustainment with IDCD.

• CTFusion must demonstrate net fusion power production in a fully integrated fusion reactor system.
CTFusion development path

**TD (Technology Demonstration Reactor)***
- Pulsed, no coil set.
- $T_o \sim 100s$ of eV

Inform optimal size and geometry of PoP.

**PoP (Proof-of-Principle Reactor)***
- Pulsed, with Cu coil set.
- $T_o \sim 1-3$ keV

Inform optimal size and material choices for DEMO.

**DEMO (Fusion power Reactor)***
- Steady-state, SC coils
- $T_o \sim 8-15$ keV

Test materials, desired end product demonstration.
Management Team

• Derek A. Sutherland, Co-Founder and CEO of CTFusion
  • B.S. double major from MIT in Nuclear Engineering and Physics
  • Ph.D Candidate at University of Washington
  • Forbes 30 under 30 in Energy for 2015.
  • Experience working on various public and private fusion ventures.

• Thomas R. Jarboe, Co-Founder and President of CTFusion
  • Leader in the development of spheromak confinement devices since the 1980s.
  • Funded by the DOE for 27 years at ~ $1M/year.
  • Discovered and patented Imposed-Dynamo Current Drive (IDCD) in 2012.

• Aaron C. Hossack, CTO of CTFusion
  • Ph.D from the University of Washington.
  • Lead experimentalist in charge of operations with over 10 years experience working on all aspects of the Gen I reactor.
Timeline of R&D and business activities

• Proto-HIT experiment from 1989-1993 at UW
• HIT experiment from 1993-1997 at UW
• HIT-II experiment from 1998-2004 at UW
• HIT-SI operated from 2004-2012 at UW

• 2011-2012: Imposed-Dynamo Current Drive (IDCD) discovered, patented, and published at UW.
• 2013-2014: Dynomak reactor vision created, patented, and published at UW.
• 2015: CTFusion formed in Seattle, WA.
• HIT-SI3 currently operating at the UW
• 2017-2018: First private fund raising round.
Intellectual property

• Three patents have been filed that are held by the University of Washington (UW).

• CTFusion has exclusive rights to these patents through a licensing agreement with the UW.

• Any additional IP created by the company is exclusively owned by the company.
Financial

Next step in development path is TD, which will require $10-15M total investment distributed over 3 years.
Key press releases and publications

Press


Publications