

**Fusion Power Plant Studies Program:  
Achievements, Recent Results, And  
The Role In The Restructured Fusion Program**

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# Recent Major Fusion Power Plant Studies in U.S.

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- TITAN reversed-field pinch
- ARIES-I first-stability tokamak
- ARIES-III D-<sup>3</sup>He-fueled tokamak
- ARIES-II and ARIES-IV second-stability tokamaks
- Pulsar pulsed-plasma tokamak
- Stellarator power plant study
- Starlite

# Elements of Fusion Concepts Studies Program

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## 1. Establish Goals and Requirements for Fusion Power.

- ★ Economics (*e.g.*, power density, recirculating power,  $\eta_{th}$ , availability).
- ★ Safety (*e.g.*, no need for evacuation), waste-disposal (Class-C waste).
- ★ Provides a common basis for comparative assessment.

## 2. Perform Self-Consistent Design & Analysis. (of both physics core and engineering components)

- ★ *e.g.*, detailed analysis of MHD equilibrium and stability and current drive subject to constraints on  $\kappa$  (vertical stability shell and coil),  $\delta$  (divertor geometry), location of kink shell (blanket design), current-drive launcher (first-wall design), core-plasma radiation (divertor design), *etc.*

# Elements of Fusion Concepts Studies Program

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## 3. Perform In-depth Analysis and Innovative and Interactive Design and Assessment. (for selected critical areas)

- ★ Trade-off of  $\beta$  and bootstrap fraction (recirculating power) which resulted in a fundamental change in direction of tokamak research and significantly influenced TPX design.
- ★ Introduction of SiC composites and associates blanket designs.
- ★ Innovative shield thermal energy storage system to remove thermal energy storage as a barrier to pulsed-tokamak power plants.
- ★ The need to operate at highly radiative core so that a compact RFP can be realized.
- ★ Development of new stellarator magnetic configurations to address the critical issue of distant between the coil and plasma.

# Elements of Fusion Concepts Studies Program

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## 4. Assess Confinement Concepts.

- ★ Concept potential versus power plant requirements (benefits).
- ★ Degree of extrapolation from present database (risk).
- ★ Identification of key issues to be addresses immediately in order to gain confidence in a concept.
- ★ Identification of innovative solutions which with R can help improve the concept.

## 5. Determine Concept Impact on Fusion Development

- ★ As a potential candidate for power plant.
- ★ As a vehicle to help fusion development path.
- ★ As a test bed to advance scientific knowledge and help optimize other concepts.

## Strength of Fusion Concepts Studies Program

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- **High-quality scientific research** through in-depth analysis and integration ensures that innovation, assessment, and design solutions are credible, meet all applicable requirements, and accepted by the scientific community.
- **Maximize use of resources** by focusing on high-leverage issues and benefiting from the participation of team members in national projects.
- **Community input and consensus** are actively sought. The team comprises key members from major fusion centers. Decision are made by consensus in order to obtain the best technical solution without institutional bias. Team is flexible and expert groups are brought in as needed. “Town meetings” and workshops are held for direct discussion and dissemination of the results.

## Strength of Fusion Concepts Studies Program

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- **Unique in the world** in ability to provide a fully-integrated analysis of power plant options including plasma physics, fusion technology, economics, safety, *etc.*
- **A high-leverage niche on the international fusion program.**
  - ★ Fusion Concepts Studies Program has provided a vision of a safe, environmentally benign, and economically competitive power plant international fusion program.
  - ★ The Fusion Concepts Studies Program is recognized internationally as a driving force towards an attractive end product (goal of U.S. fusion program).
  - ★ This vision is having an impact on international fusion program plans and scientists.
  - ★ This is witnessed by the international collaboration in this area, especially the long-term visits (a couple of months to a year) by international scientist to work with us.

# Needs of the Restructured Fusion Program

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- High-leverage **World Leadership** and potential to influence the direction of international fusion research.
- A connection to the **Energy Goal** of the program.
- Identification of critical and high-leverage issues for the **Scientific Focus**.

# Role of Fusion Concepts Studies Program in the Restructured Fusion Program

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- Focus on concepts improvement and alternate fusion concepts.
- Emphasize the identification of critical and high-leverage issues that should be addressed as part of next-step experimental and theoretical research.
- Emphasize and identify the potential of innovative fusion concepts as a (a) potential candidate for power plant. (b) vehicle to help fusion development path. (c) test bed to advance scientific knowledge and help optimize other concepts.
- Provide both short-term (a couple of months) assessments as needed by the program as well as longer (12-18 months) detail innovation and design analysis.
- Rename the program to reflect the scientific focus, *e.g.*,

**Fusion Concept Innovation, Design, and Assessment  
Studies Program (Fusion Concept IDEAS)**

# The Starlite Project

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- The Starlite project has developed and applied the principles of fusion concept innovation, design, and assessment:
- We have:
  - ★ Developed requirements and goals for fusion commercial and demonstration power plants.
  - ★ Developed methodology for assessing key plasma physics and fusion technology areas.
  - ★ Assessed of physics operating regime (pulsed-plasma, first-stability, second-stability, reverse-shear, and low-aspect ratio).
  - ★ Assessed of fusion technology data base.
- The reverse-shear plasma and advanced Li/V blanket option were chosen for detailed design which is in progress.