PREAMBLE
I agree with many of the sentiments put forth by my IFE colleagues...

• Community collaboration to create IFE program

• Competition between concepts

• Integrated approaches

• Phase I: $200 M/year x 5 years is appropriate level

• Program pace/down select given by:
  • technical progress
  • **credible potential for an attractive reactor**
The need for a (n Inertial) Fusion Engineering Test Facility

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Four light bulbs lit by the first electricity generated by a fission reactor (EBR-1 at INL in 1951)
Basic Premise: The path to fusion energy should have an Engineering Test Facility

- Allow a potential investor to confidently evaluate the practicality of fusion energy
- Provide a research vehicle to address optimization, integration, and sustained operation in a nuclear fusion environment
Fusion is a way to make electricity.

There are already many ways to make electricity!
To be “taken seriously,” fusion must have some meaningful advantages over existing, and future, energy sources.

Examples:
- Cost to Develop
- Cost to Build
- Cost to License
- Cost to Operate
- Cost to Decommission
- Environmental considerations
- Safety
- Availability
- Reliability
- Non-proliferation
An Engineering Test Facility is needed so a potential investor* can confidently evaluate these advantages.

Show technologies that credibly lead to attractive:

**Power Plant Issues**
- Maintenance, Availability, and Reliability
- Costs of all kinds
- Safety, environment, licensing

**Fusion Issues**
- Performance (gain)
- Required precision and integration
- Breeding, Refueling and Power Handling

*Investor could be Government, Industry or both.
The Engineering Test Facility should also be a research tool.

- Optimize target performance
- Develop nuclear resistant materials and structures

- Neutrons emitted by point source
- Chamber wall, far away, has long life (2 dpa/yr)
- Samples and structures close in get prototypical neutron exposures (up to 50 dpa/yr, 21 liter volume)

- Address integration issues
- Take care of everything else that comes up
Where the Engineering Test Facility fits in the path to develop fusion energy

**Stage I: Develop full size components**
- Laser module (e.g. 17 kJ, 5 Hz KrF beamline)
- Target fabrication/injection/tracking
- Chamber, optics technologies
- Refine target physics
- Power plant/FTF design

**Stage II: 100 MW Engineering Test Facility (ETF)**
- Demo physics / technologies for a power plant
  - $\eta_G$: 7 - 10, $G$: 100 - 140
- Tritium breeding, power handling
- Develop/ validate fusion materials
- Operating: ~2025

**Stage III: Prototype Power plant(s)**
- Electricity to the grid
- Transitioned to private industry
Some functional requirements for the Engineering Test Facility

- Performance ($\eta G$ and $G$)
- Breeding
- The keys to economical availability and reliability
$\varepsilon = \text{conversion efficiency, } \eta = \text{driver efficiency, } G = \text{gain, } \beta = \text{Burnup in blanket}$

\[
\text{Electrical Power to Grid} = \varepsilon P \beta G - \frac{P}{\eta}
\]
Lower cost and higher performance favors lower recirculating power fraction \( (f = 1/\varepsilon\eta\beta G) \).

Recirculating Power vs \( \eta G \) (\( \varepsilon = 40\% \), \( \beta = 1.1 \))

- \( \eta G < 2.5 \ldots f = 1 \): can’t power itself
- \( \eta G = 10 \): \( f = 0.25 \) recirculating power
- \( f < 0.1 \): typical fission plant

Suggested ETF Design point
Higher gain (G):
1) More electrical power output
2) Smaller (lower cost) driver
3) Trumps driver efficiency

Electric Power (P_g) / Laser Power (P_{laser}) vs gain

\[ \frac{P_g}{P_{laser}} = \varepsilon \beta G^{-1/\eta} \]

7% increase in gain = 2x increase in efficiency

\eta = 28% (\varepsilon = 40\%)  
\eta = 14% (\beta = 1.1)  
\eta = 7%
EXAMPLE: New Direct Drive Designs predict enough gain for energy:

- **Shock Ignition (248 nm)**
- **Fast Ignition**
- **Conventional Direct Drive**
  - KrF (248 nm)

Laser Energy (MJ) vs. Target Gain

- **L-UR**

References:
1. Betti, 2006
2. Schmitt, 2010
The need to breed

Tritium required vs availability
(30 MJ/shot, 5 Hz)
The two keys to economically attractive Availability and Reliability are Simplicity and Durability.
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