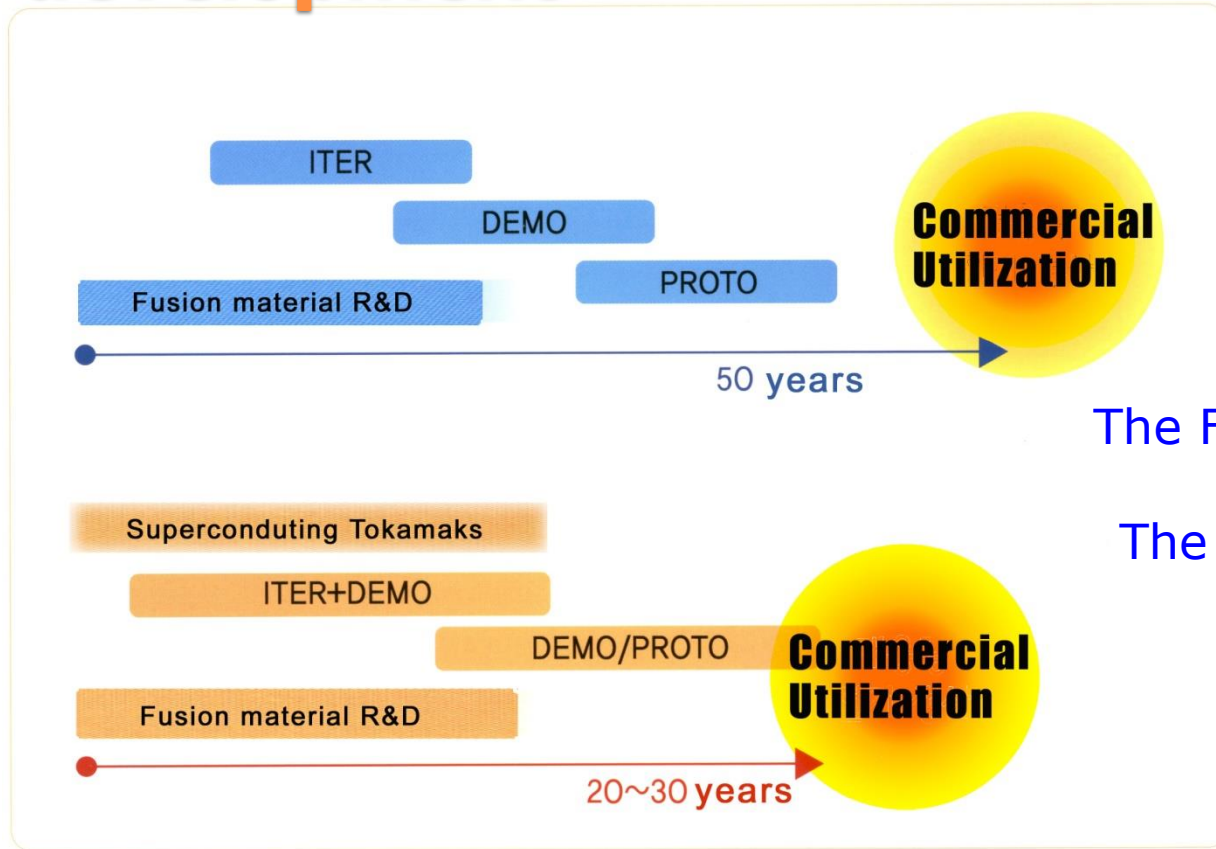


Fusion Reactor Technology I

(459.760, 3 Credits)

Prof. Dr. Yong-Su Na
(32-206, Tel. 880-7204)

Phased integration of reactor technology development



The Fast Track Approach
&
The Broader Approach

- DEMO: The last integrated machine funded by the government to demonstrate electricity generation in a plant scale.

세계 핵융합에너지 개발 현황

- 미국 “핵융합 아폴로 프로그램” 시급히 추진 필요
 - 향후 10년간 핵융합 아폴로 프로그램(300억\$ 투자)을 조속히 추진하여 청정·안전·대량·안보 에너지원의 확보가 시급함을 주장
- 중국 “2015년 CFETR(독자 핵융합 실증로) 개발 착수 계획”
 - 핵융합 에너지 개발이 포함된 중국 국가중장기과학기술연구시설 개발프로그램 (2012~2030)이 주 의회로부터 발표되었으며, 2015년에 CFETR(독자 핵융합 실증로) 개발을 착수하는 등 핵융합 에너지 개발에 대해 다소 공격적인 전략으로 조속히 추진하고 있음
- EU, 2012 로드맵 발표 “2020년 ITER 건설, 2050년 DEMO 시장진입”
 - 향후 에너지 정책에 따른 CO₂ 감소와 함께, 핵융합은 약 2050년에 시장 진입을 시작할 것이며 2100년까지 전력생산의 30%를 차지할 것으로 전망

해외 현황

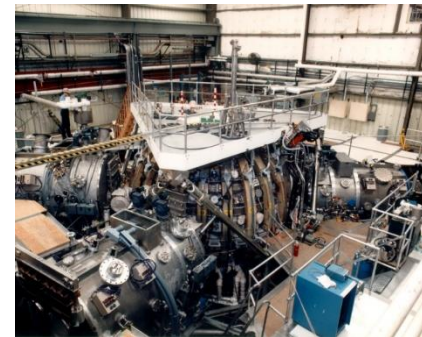
➤ 해외 ITER 참여국의 핵융합 연구 현황

■ 미국

- 경제성을 고려한 소형 핵융합로 프로토타입 SPARC 개발 프로젝트 추진
- 가열장치 개발용 중성자 빔 기술 개발, 전산 기술을 활용한 핵융합로 설계 최적화
- 약 1,500명의 핵융합 종사자와 1조 3,500억 예산 투자

■ EU

- 2050년대 DEMO 전기 실증을 목표로 로드맵 작성 및 핵융합에너지 8대 과제 선정
- 중성자조사시설 IFMIF-DONES 공학설계 개발 프로젝트 계획 수립, 일본과 공동으로 IFMIF/EVEDA 프로젝트 추진
- 약 3,000명의 핵융합 종사자와 9,000억 예산 투자 (Eurofusion 및 ITER 지원 예산)



해외 현황

■ 일본

- 2050년 경 DEMO 운전 개시 로드맵 제시
- 2025년 중성자조사시설 A-FNS 건설 착수 및 2030년대 활용 예정
- EU와 공동으로 IFMIF/EVEDA 프로젝트 추진
- 약 700명의 핵융합 종사자와 3,000억 예산 투자



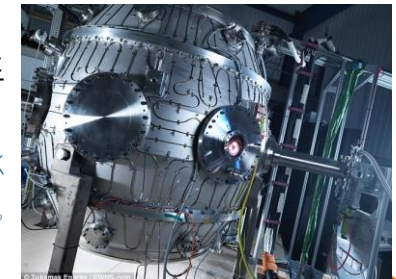
■ 중국

- CFETR 건설을 중심으로 로드맵 설계 및 관련 연구 시설 CRAFT 건설 착수
- 초전도자석 기술 및 토카막 시스템공학 설계 R&D 중점 투자
- 약 2,700명의 핵융합 종사자와 3,000억 예산 투자

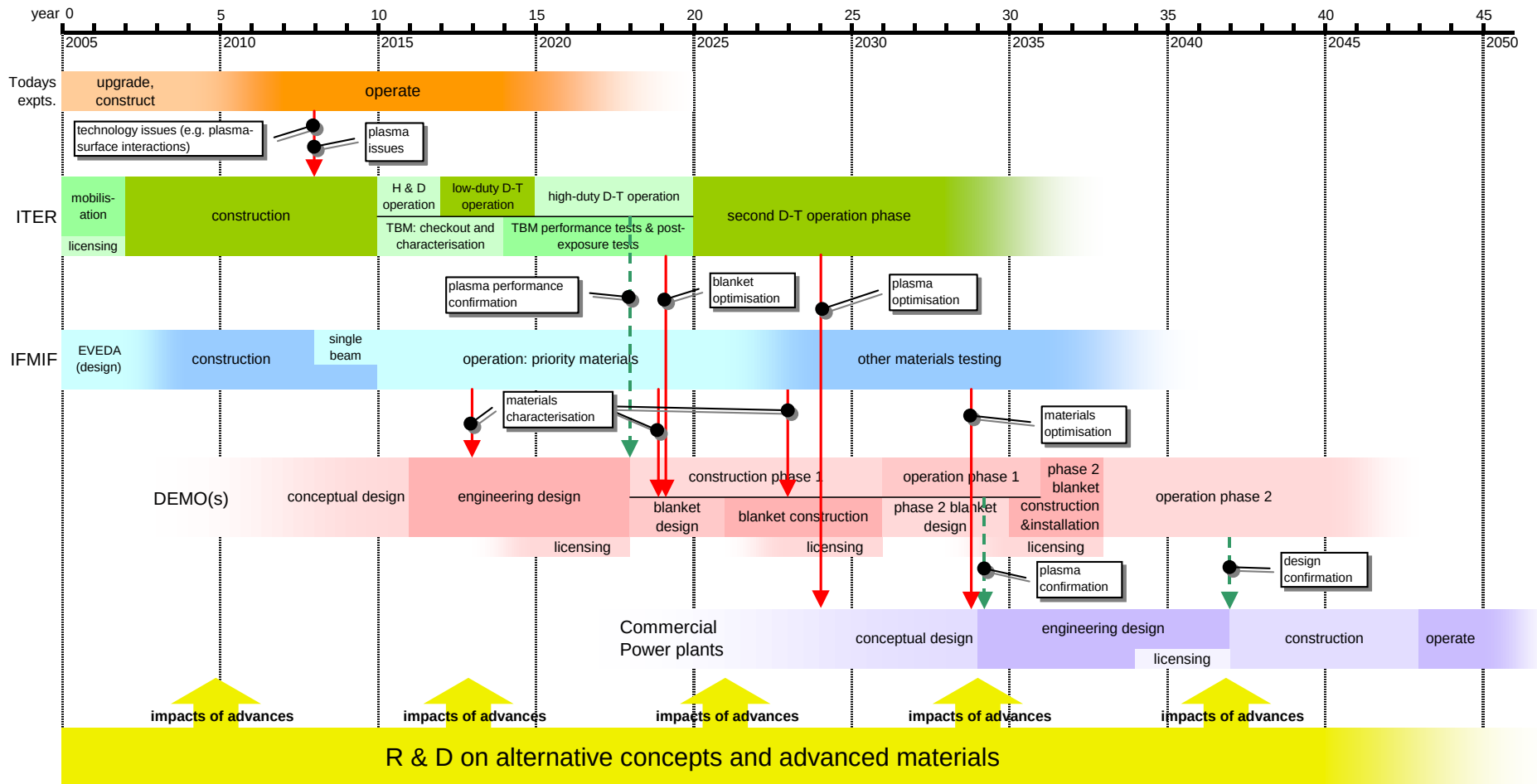


■ 영국

- 2040년 세계 최초 전력생산 가능한 소형 구형 토카막 STEP 건설 착수 및 운영 목표
- 산학연 협력기반 ITER DT 단계 이전 공학 설계 로드맵 작성
- 원자력 투자, SMR 개발과 함께 '40년 핵융합에너지 상용화 선언



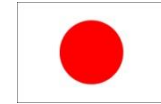
Phased integration of reactor technology development



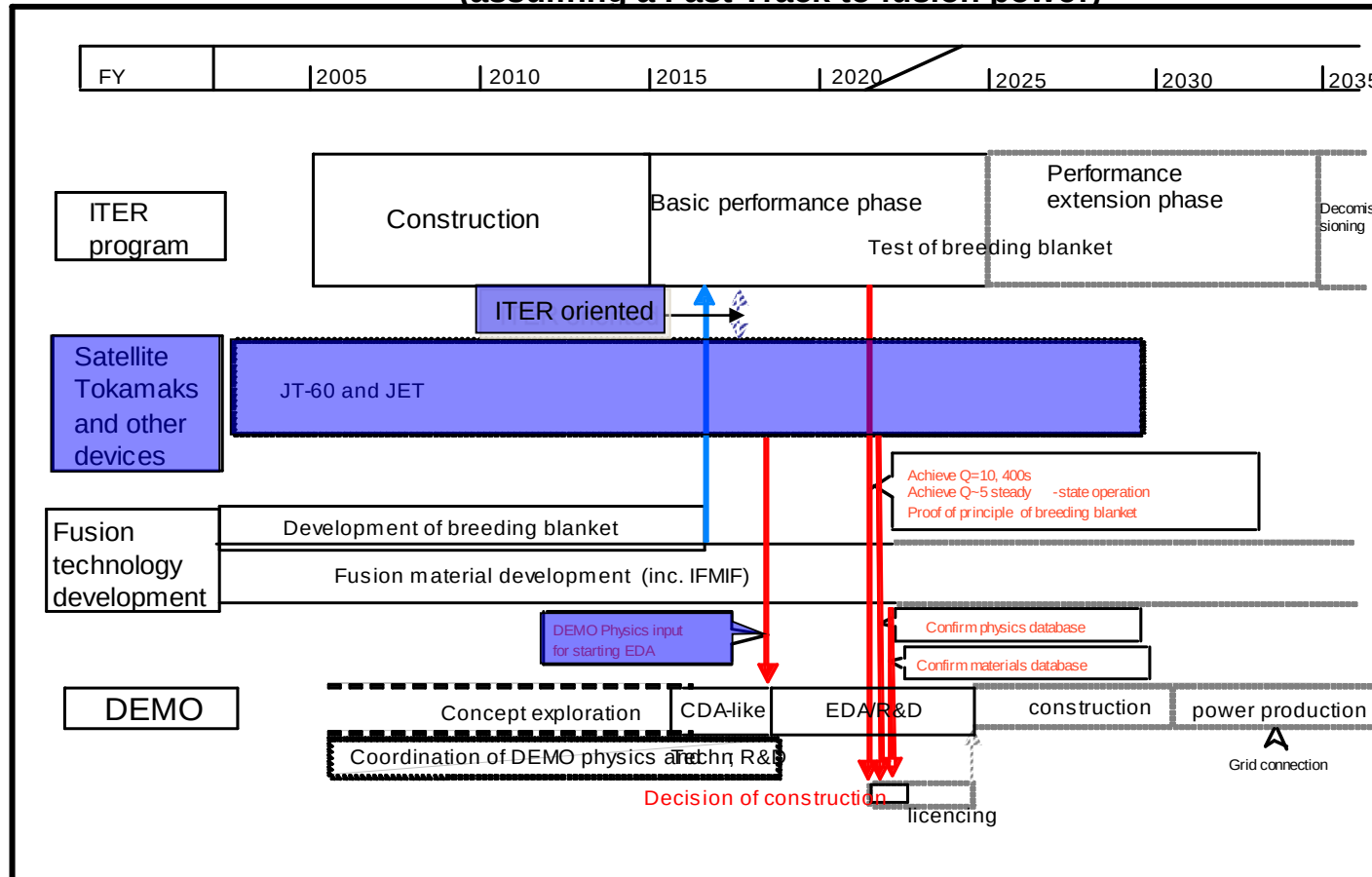
"The Path to Fusion Power"

by C. L. Smith (Director, UKAEA Culham), KAST (10 October, 2006)

Phased integration of reactor technology development

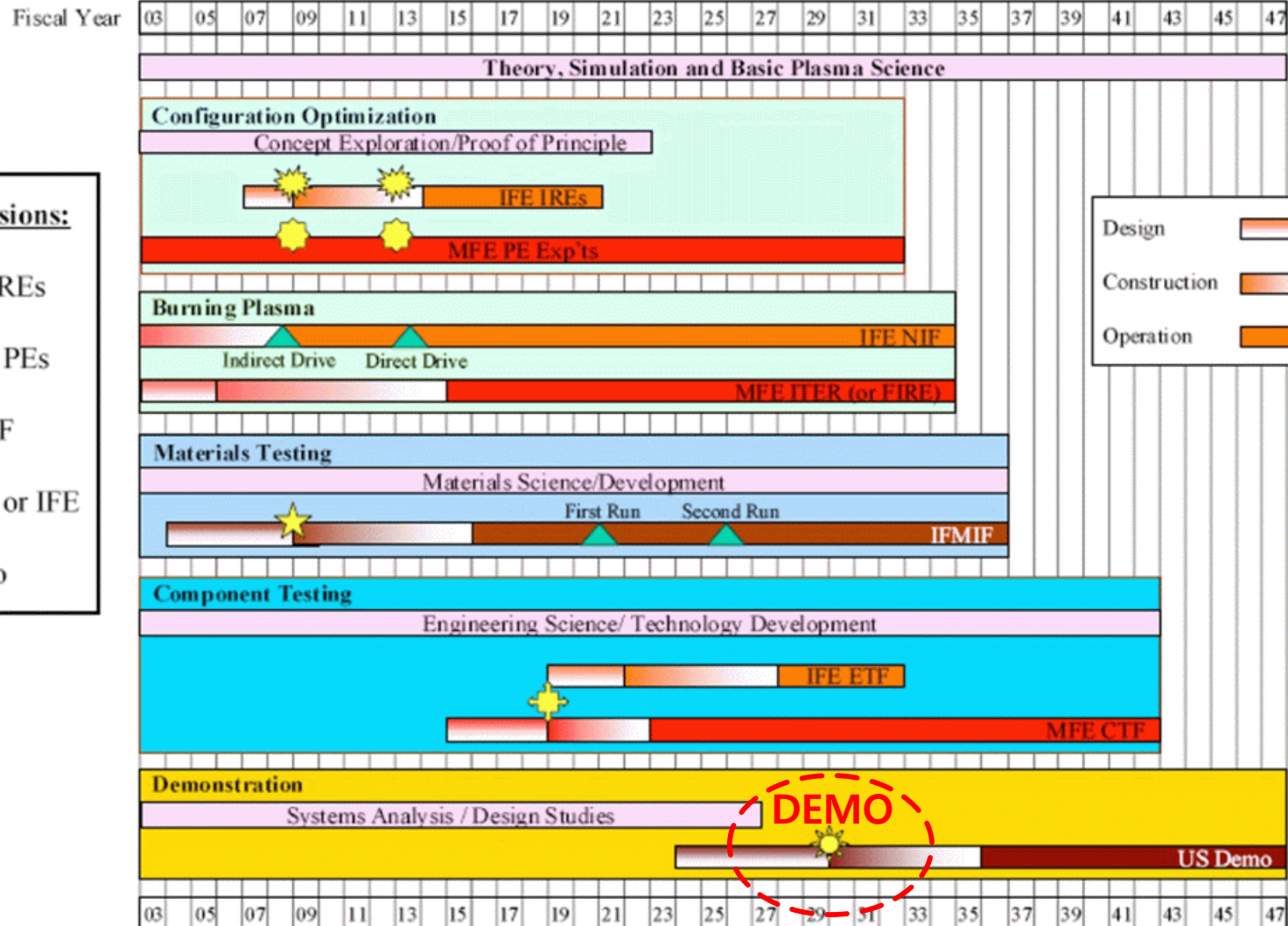


The broader approach leading to construction of DEMO
(assuming a Fast Track to fusion power)



"Overview of NCT Proposal" M. Kikuchi (November 3-4, 2005)

Phased integration of reactor technology development



Key Decisions:

- ☀ IFE IREs
- ☀ MFE PEs
- ★ IFMIF
- ✚ MFE or IFE
- ☀ Demo

- Design
- Construction
- Operation

Phased integration of reactor technology development



Strategic Timeline—Fusion Energy Sciences*

2003 2005 2007 2009 2011 2013 2015 2017 2019 2021 2023 2025

The Science

Burning Plasma Demonstration

- Initiate experiments on the National Ignition Facility (NIF) to study ignition and burn propagation in IFE-relevant fuel pellets (2012)

ITER

- Complete ITER experiments to determine plasma confinement in parameter range required for an energy-producing plasma (2017)

- Complete experiments on NIF to advance the science of ignition and burn propagation needed to design optimized fuel pellets for an Inertial Fusion Energy plant (2020)
- Complete experiments on ITER to determine the impact of the fusion process on the stability of energy-producing plasmas (2020)

- Achieve high fusion power for long durations on ITER to define engineering requirements for fusion power plants (2025)

Fundamentals of Plasma Behavior

Tokamaks

- Achieve a fundamental understanding of tokamak transport and stability in pre-ITER plasma experiments (2009)

- Major aspects relevant to burning plasmas are observed in experiments prior to full operation of ITER are produced with high accuracy and are understood (2015)
- Determine the physics limits that constrain the use of inertial fusion energy drivers in future key integrated experiments needed to resolve the scientific issues for inertial fusion energy and high-energy density physics (2015)

Fusion Simulation Project

- Deliver a complete integrated simulation of a power-producing plasma, validated with ITER results, that enables the design of fusion power plants (2020)

Plasma Confinement

NSTX

- Achieve long-duration, high-power, well-controlled plasmas in a spherical torus sufficient to design and build fusion power-producing Next-Step Spherical Torus (2008)

- Demonstrate the ability of a compact, self-generated plasma current to achieve high-pressure/well-confined steady-state operation for ITER (2008)

- Evaluate the feasibility/attractiveness of potential drivers, including heavy ion beams, dense plasma beams, and laser for fusion approaches involving high-energy density (2009)

NCSX

Next-Step Advanced Facility

- Resolve key scientific issues and determine the confinement characteristics of a range of attractive confinement configurations (2015)

- Determine the potential of one or more of the promising plasma configurations (for example a spherical torus) for use as a component test facility or a fusion power source (2020)

Materials, Components, and Technologies

- Start production of superconducting wire needed for ITER magnets (2006)

- Deliver to ITER for testing the blanket test modules needed to demonstrate the feasibility of extracting high-temperature heat from burning plasmas and for a self-sufficient fuel cycle (2013)

Component Test Facility

- Complete first phase of testing in ITER of blanket technologies needed in power-producing fusion plants capable of extracting high-temperature heat from burning plasmas and having a self-sufficient fuel cycle (2020)

- Complete first round of testing in a component test facility to validate the performance of blanket technologies needed for a power-producing fusion plant (2025)

Future Facilities**

"The Development Path for Magnetic Fusion Energy" by R. Goldston (Director, PPPL) Global Climate and Energy Project Workshop on Fusion Energy (1 May, 2006)

*These strategic milestones are illustrative.

**For more detail on these facilities

Facilities for the Future of Science: A Twenty-Year Outlook.