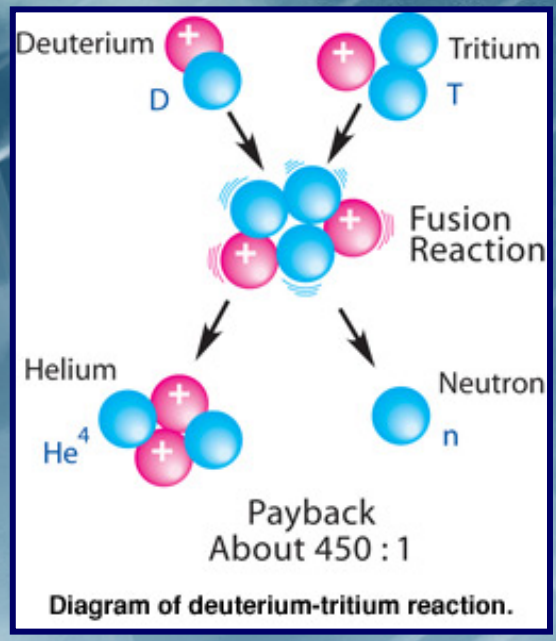
Why Fusion?

The Politics and Policy of Energy in the United States



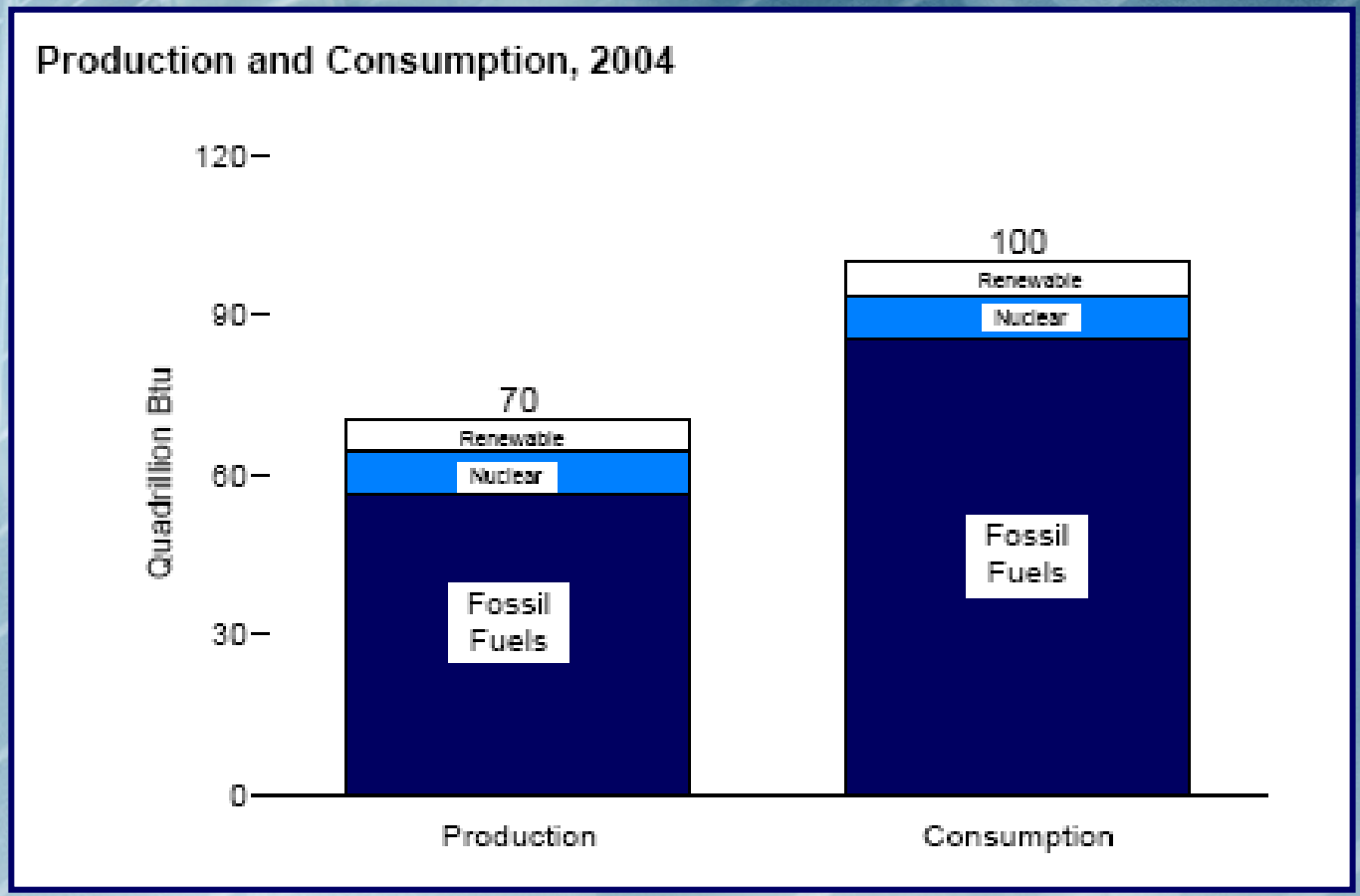
Courtesy of Princeton Plasma Physics Laboratory.

Laura Jacox and Jessica Lynch

The History of Energy in America

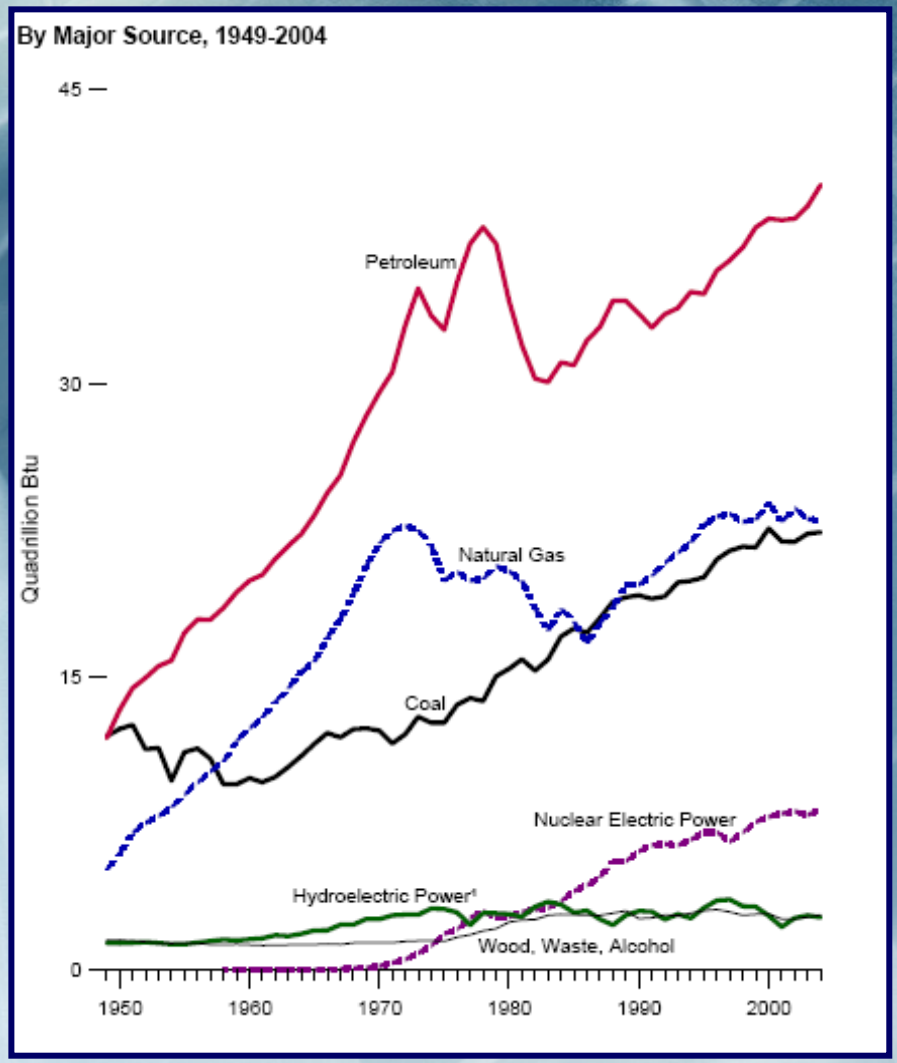
- 1850s- 90% of energy consumed came from burning wood
- 1910- coal replaced wood as dominant energy source – 70% of energy consumed
- 1970s- oil and gas reached 70% mark

Current U.S. Energy Production & Consumption



http://www.eia.doe.gov/emeu/aer/pdf/pages/sec1_4.pdf
Courtesy of U. S. Department of Energy.

U.S. Energy Consumption Over Time



http://www.eia.doe.gov/emeu/aer/pdf/pages/sec1_8.pdf
Courtesy of U. S. Department of Energy.

Effects of Coal-Mining

- Mining
  - habitat destruction
  - landscape leveling
  - hydrological disruptions
  - acid leaching

Courtesy of Pacific Northwest National Laboratory.

Courtesy of USGS.

Environmental Impacts of Coal

- Processing/Use
  - air pollution (particulate matter, smog)
  - water pollution (SO_2, NO_x– acid rain)
  - climate change and global warming- CO_2 emissions

Courtesy of USGS.

http://pubs.usgs.gov/fs/fs-016-03/images/coalplant.jpg

Drilling for Oil and Natural Gas

- Drilling
  - habitat destruction
  - drilling structures, access roads, pipelines

Photos removed for copyright reasons.

Environmental Impacts of Oil

- Processing/Use
  - air pollution, oil well fires
  - oil spills- Exxon Valdez
  - water pollution
  - climate change, global warming- CO_2 emissions

Courtesy of U.S. Army.

Photo courtesy of US Environmental Protection Agency.

Oil Exploration: The ANWR Debate

- ANILCA
- proponents: increase energy security, jobs for Americans
- opponents: environmental destruction, oil yield not worth costs

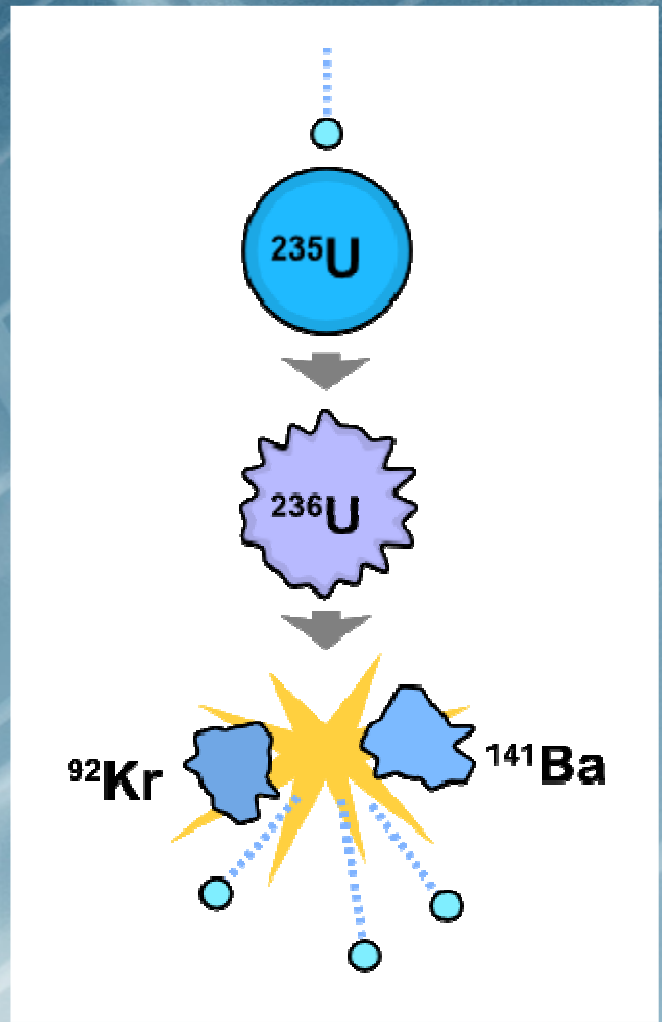
http://arctic.fws.gov/

Courtesy of U.S. Fish and Wildlife Service.

How About Nuclear Power? Pros

- no GHG emissions
- no risk of acid rain/air pollutants
- abundant fuel supply

Courtesy of Stefan Kuhn. Source: Wikipedia.



Source: Wikipedia.

Nuclear Power: Cons

- Mining ^{235}U releases radioactivity
- Habitat destruction
- Nuclear proliferation risk
- Risk of a meltdown
- Thermal pollution
- High-level radioactive waste

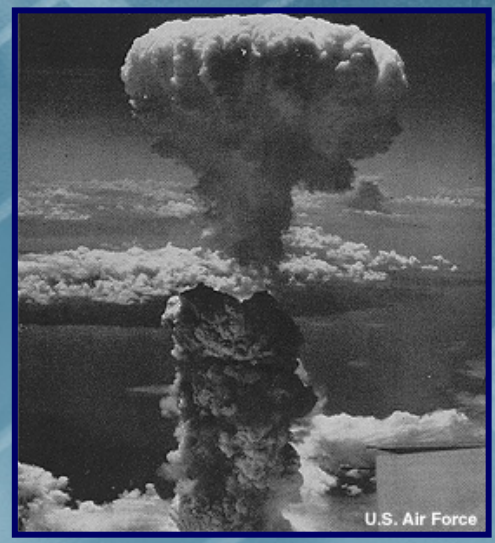


Photo removed for copyright reasons.
See http://www.wma-minelife.com/uranium/mining/graphics/swtste6b.jpg

Fusion- The "Energy of the Stars"

- Fewer radioactive products generated as compared to fission
- Abundant fuel- deuterium can be isolated from seawater
- Tritium can be bred from lithium- available in land and see deposits
- No carbon emissions
- No risk for meltdown- fuel in reactor for less than 5 minutes
- No nuclear proliferation risk
- Cost estimated to equal that of coal or fission

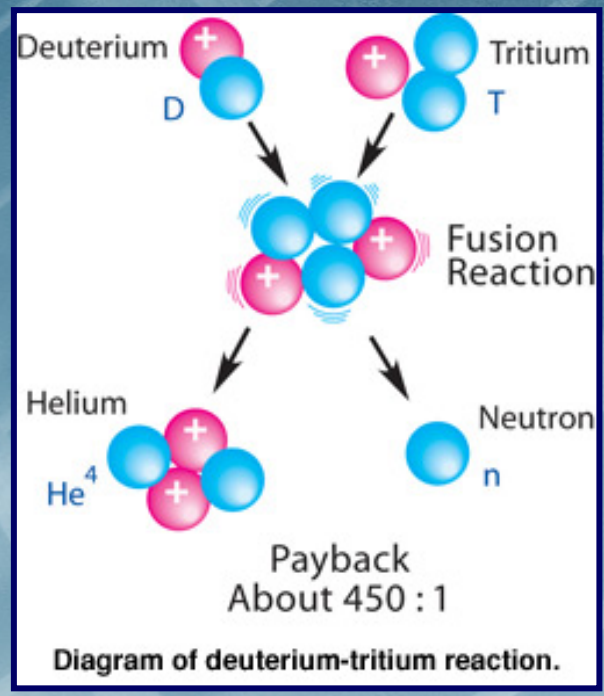


Diagram of deuterium-tritium reaction.

http://www.pppl.gov/common_pics/fusion_energy_program.pdf

Courtesy of Princeton Plasma Physics Laboratory.

Comparing Energy Sources

	Coal	Fission	D-T Fusion
Fuel quantity	9000 T	1 kg U-235	1 lb. D_2, 3 lb Li^6
waste	30,000 T CO_2, 600 T SO_2, 80 T NO_x	25 T. U-235, 250 kg ^{239}Pu	4 lb. He^4
Fuel Supply	Decades	Millions of yrs.	Millions of yrs.
Fuel Issues	Envt. Problems w/ extraction	Fuel radioactive	Tritium radioactive
Rxn. Products	GHG, smog, acid rain	radioactive	Products not radioactive
Runaway rxn?	Fire hazard	Meltdown	none

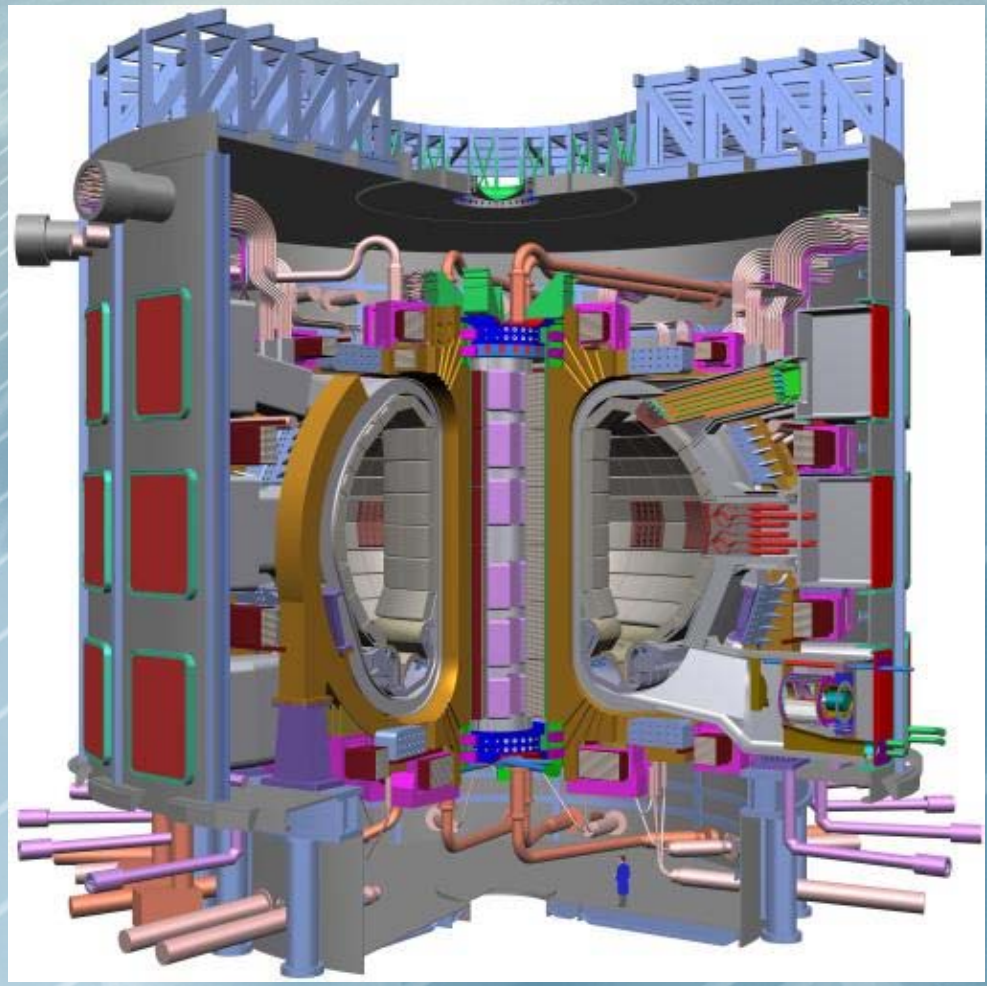
http://www.focusfusion.org/what/chart.html http://www.pppl.gov/fusion_basics/pages/fusion_advantages.html http://www.lbl.gov/abc/wallchart/chapters/14/1.html

Fusion Funding

- Increased over the past ten years
- In 2007, the White House asked Congress to boost energy science spending
- Budget request would increase funding for fusion energy program by $31 million

Future Fusion Funding

- Administration said it would like to double the DOE's science budget by 2016
- "Protecting America's Competitive Edge" (PACE) bills introduced in Congress
- Would double funding for R&D



http://www.iter.org/index.htm

ITER:

The Next Step in Fusion Research

The Beginning

- International Fusion Research Committee proposes that participants work together on an International Toroidal Reactor (INTOR)
- Arms race between USSR and the US
- Fusion is ideal arena for compromise- not defense related

http://en.wikipedia.org/wiki/Nuclear_arms_race

US and USSR/Russian nuclear weapons stockpiles, 1945-2005.

The Beginning

- Gorbachov proposes idea of Fusion initiative to Reagan at Geneva Summit in 1985
- Nuclear disarmament standoff prompted U.S. to respond with a proposal
- Collaboration resulted in the establishment of International Thermonuclear Experimental Reactor

http://www.gwu.edu/~nsarchiv/NSAEBB/NSAEBB172/

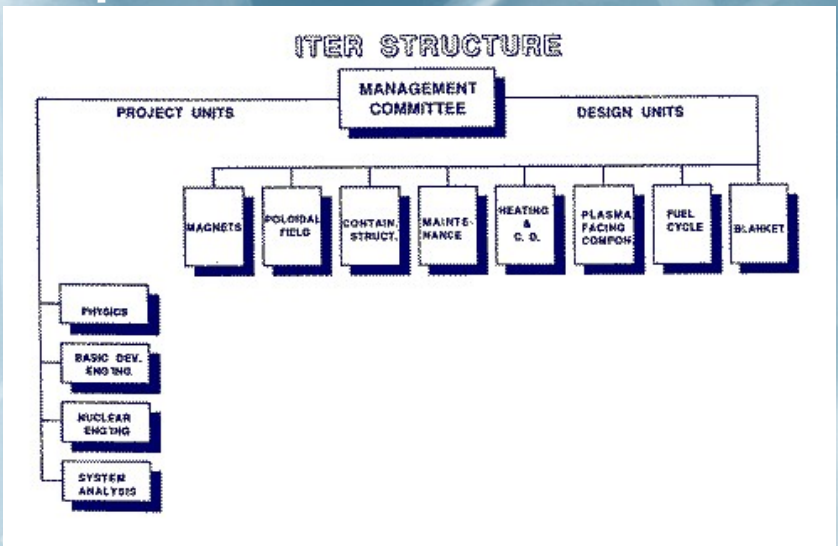
Courtesy of U.S. National Archives and Records Administration, Ronald Reagan Library.

Conceptual Design Activities

- Objective: "demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes."
- ITER project was controlled by the Conceptual Design Activities (CDA) group starting in April 1988.

Design Groups for the CDA

http://www.iter.org/index.htm



Engineering Design Activities

- CDA replaced by the Engineering Design Activities (EDA) program in 1990
- Contributing parties conduct further R&D-share information
- Cannot decide where R&D should occur so they split the EDA design team into three groups that operate in three locations: Garcing, Germany, Naka, Japan, and San Diego, USA

Photo removed for copyright reasons.
Signature of the ITER EDA Agreement in 1992.

America Withdraws

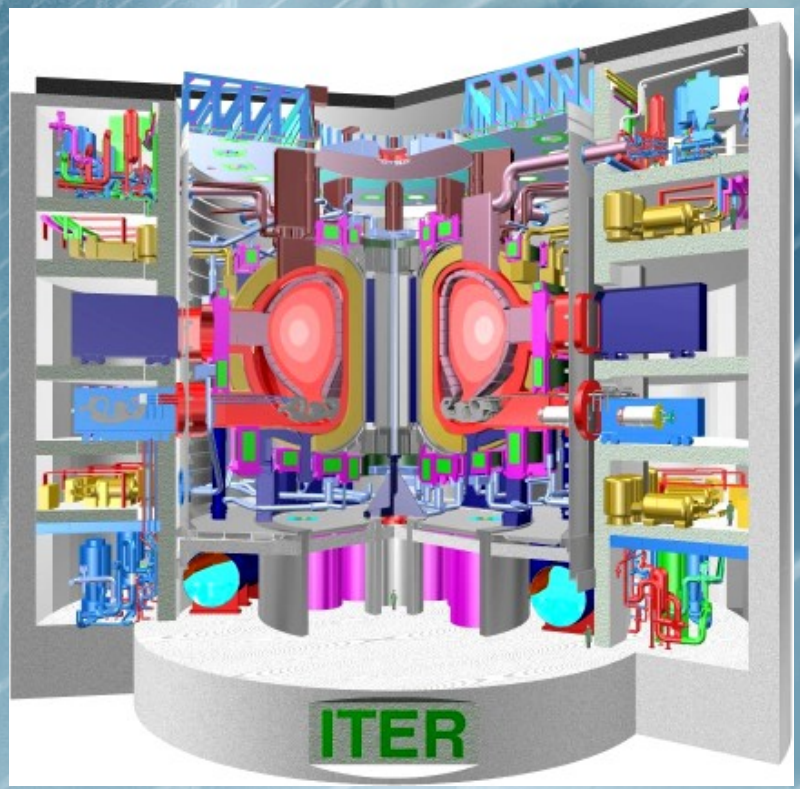
- EDA culminated in a complete engineering design of ITER in 1998.
- America was an equal party in the ITER program throughout EDA
- In 1998, Congress directed the Department of Energy to end U.S. participation in the project.
- U.S. had invested $350 million dollars
- ITER deemed too expensive as the price tag continued to rise

America Rejoins

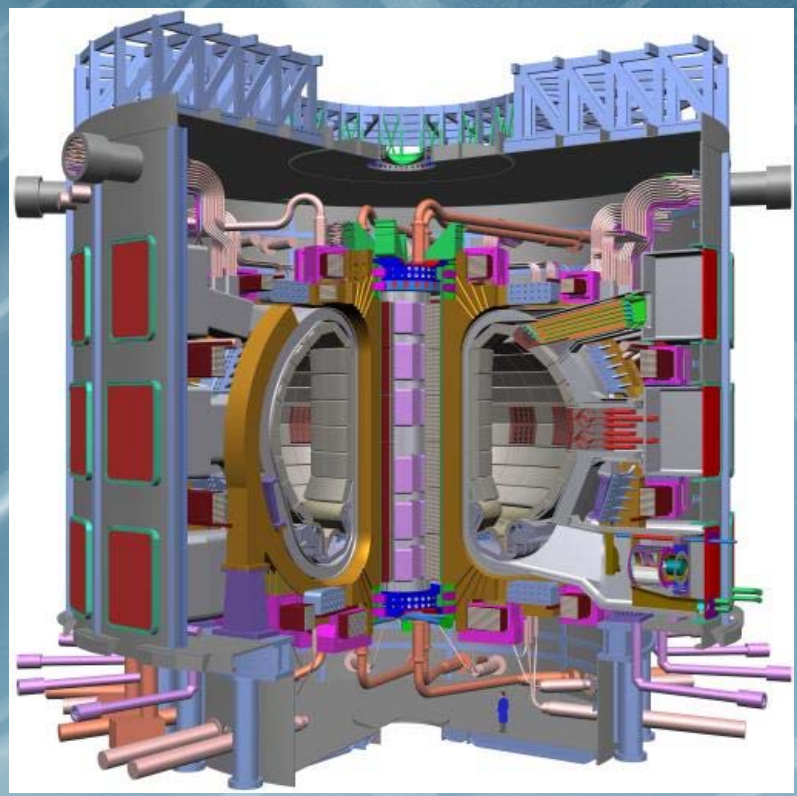
- ITER Parties redesign sections to reduce cost
- President Bush announced that the U.S. would rejoin with the new reduced cost
- Energy Department promised up to 10% of the then $5 billion dollar project.
- Bush announced that, "the results of ITER will advance the effort to produce clean, safe, renewable, and commercially available fusion energy."

http://en.wikipedia.org/wiki/George_W._Bush

Original & Revised Tokomac Designs



ITER 1998 Design



Revised Design

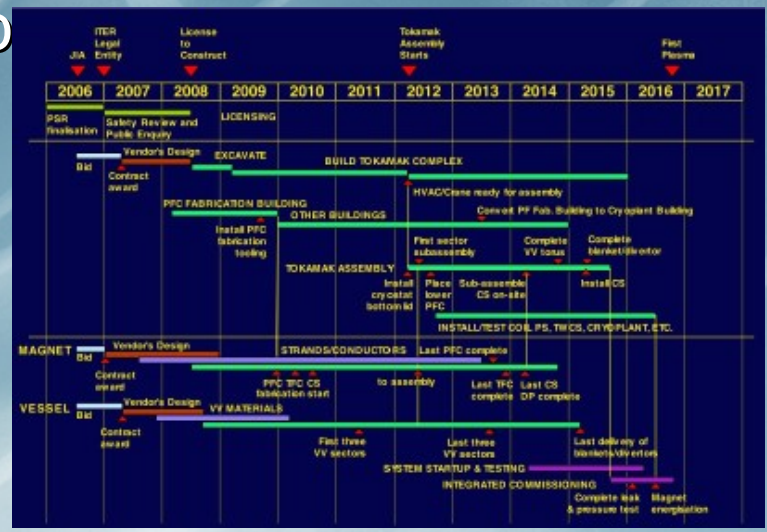
http://www.iter.org/index.htm

Choosing a Site to Build ITER

- Participants unable to agree on a location to build ITER for several years
- Bitter fight between representatives who wanted the site in Cadarache, France and those who wanted it in Rokkasho, Japan.
- In June 2005, the countries decided to build ITER in Cadarache, France
- In exchange for building the site in France
  - EU will pay half the costs of the project
  - Japan will also have twenty percent of construction contracts and jobs
  - demonstration reactor will be built in Japan after fusion technology is refined.

ITER's Timeline

- Compromise was a great success
- Years of disagreement pushed back the construction of ITER
- ITER is scheduled to open in 2016 and construction will begin the summer of 2006
- R&D is still being conducted at two Joint Work Sites which include Naka, Japan and Garching, Germany
- ITA program is scheduled to end when participants ratify the Joint Implementation Agreement which will form the ITER Organization



Published with permission of ITER.

"The Next Step" Device

- Researchers hope that ITER will be the first experiment where fusion breaks energetically even or produces more energy than invested.
- If ITER succeeds, it will provide concrete evidence that we can come to depend on an abundant and benign alternative form of fuel
- Gain economic independence from fossil fuels
- Slow destruction of environment
- Collaborative efforts of nations will hopefully produce the key to the next generation's source of sustainable, reliable, and clean energy.

"The Next Step" Device