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Energy, climate, and the role of fusion as a transformational science

Presented by:

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U.S. Department of Energy

For the 1st Monaco-ITER International Fusion Energy Days
Principality of Monaco
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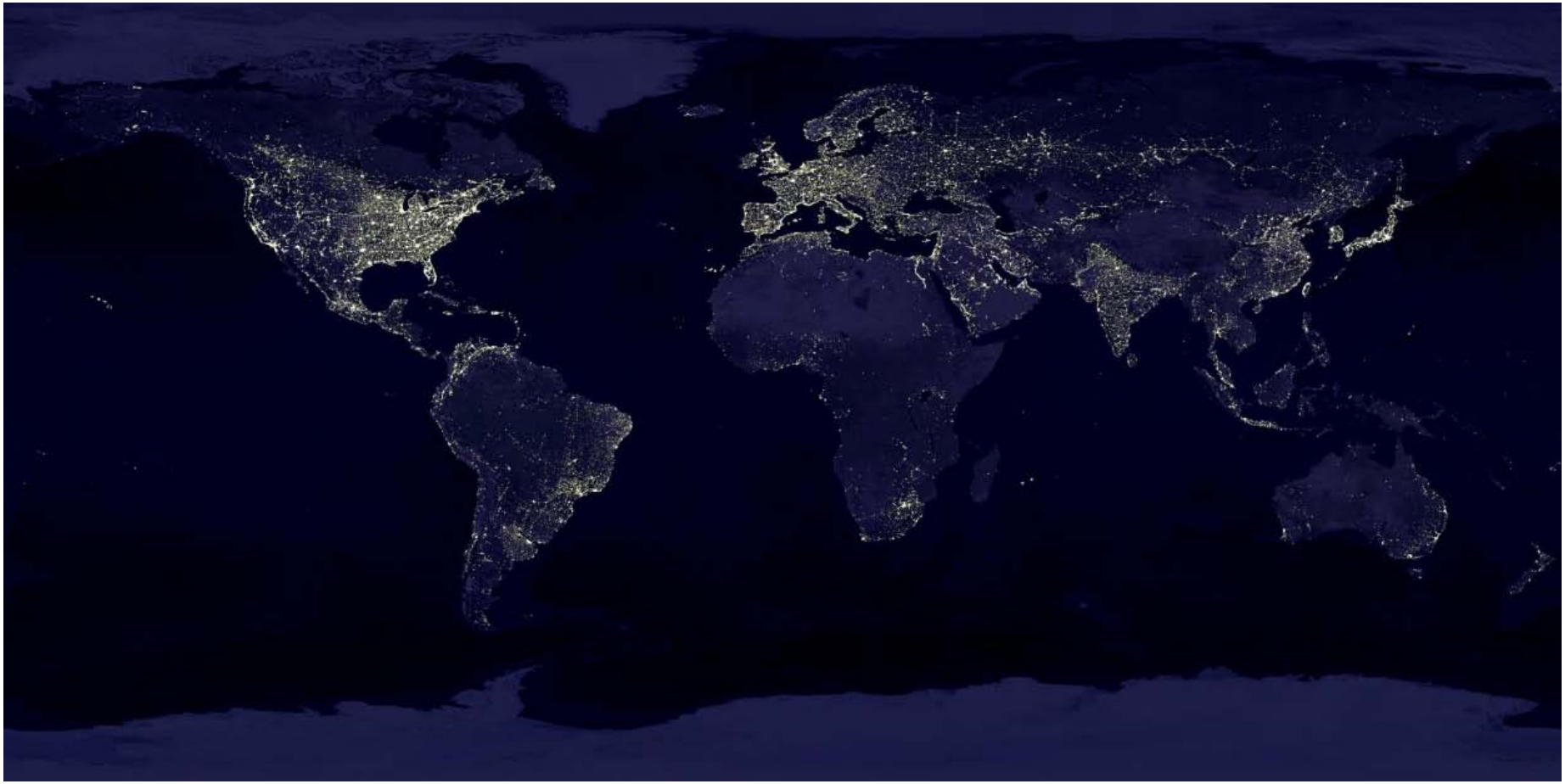
Our ambition has to be commensurate with the challenges of the times



- *For fusion, the ambition is to power the planet* with a carbon-free energy source

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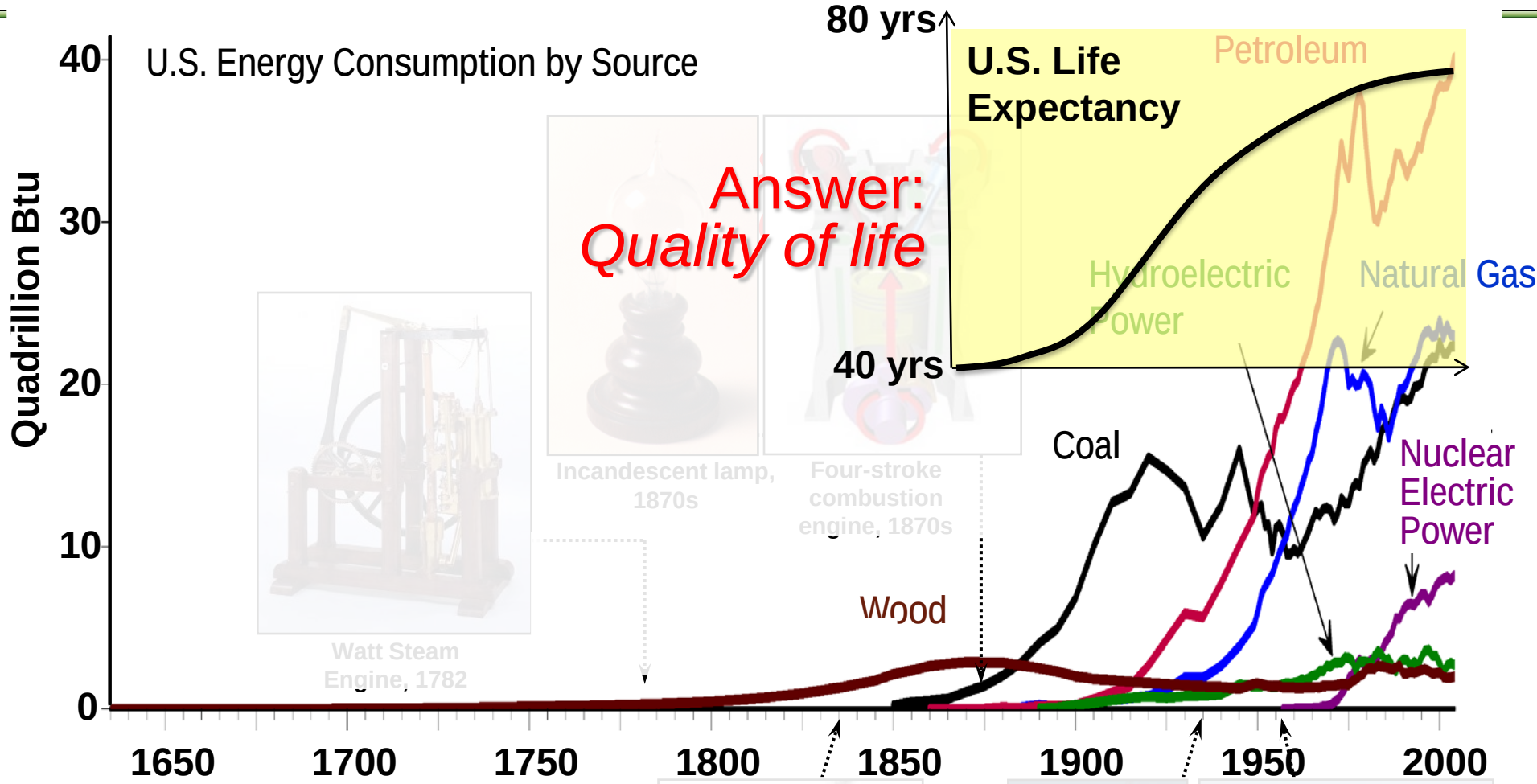
Question: Why energy?



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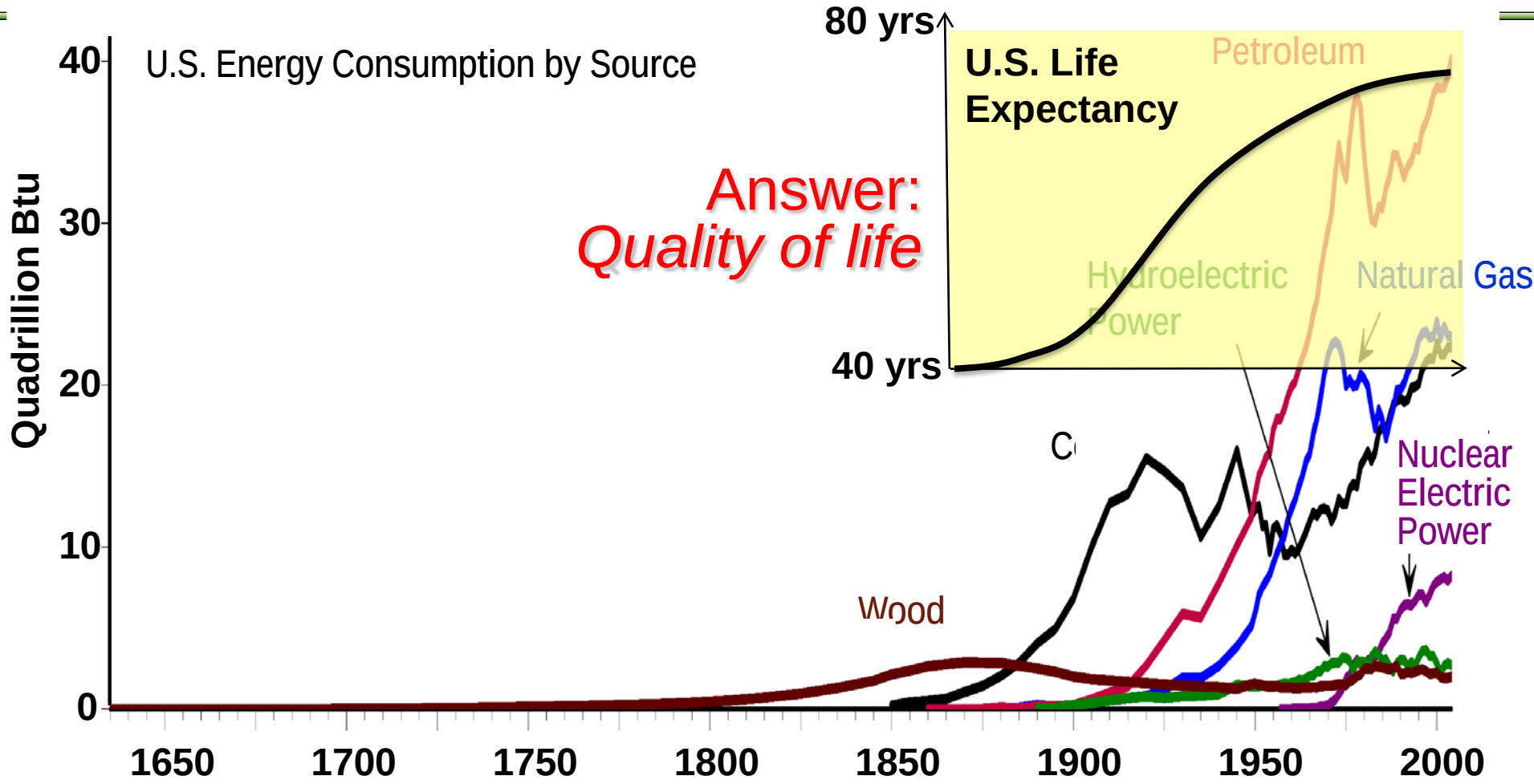

Answer:
Quality of life

- Innovation and economic growth following the industrial revolution fueled dramatic increases in the quality of life in the U.S..

- Fusion, as one element of transformational science, can provide a path to a sustainable future

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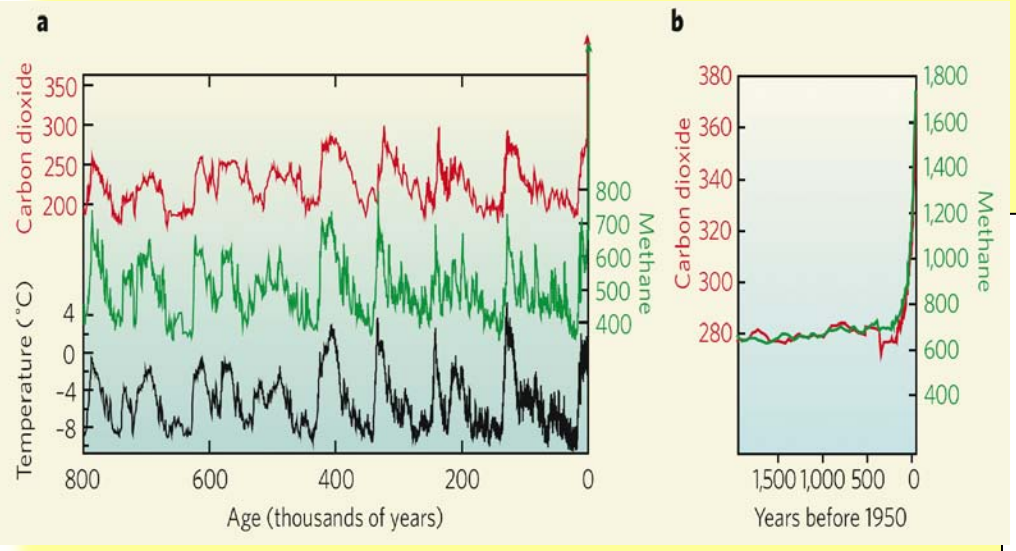
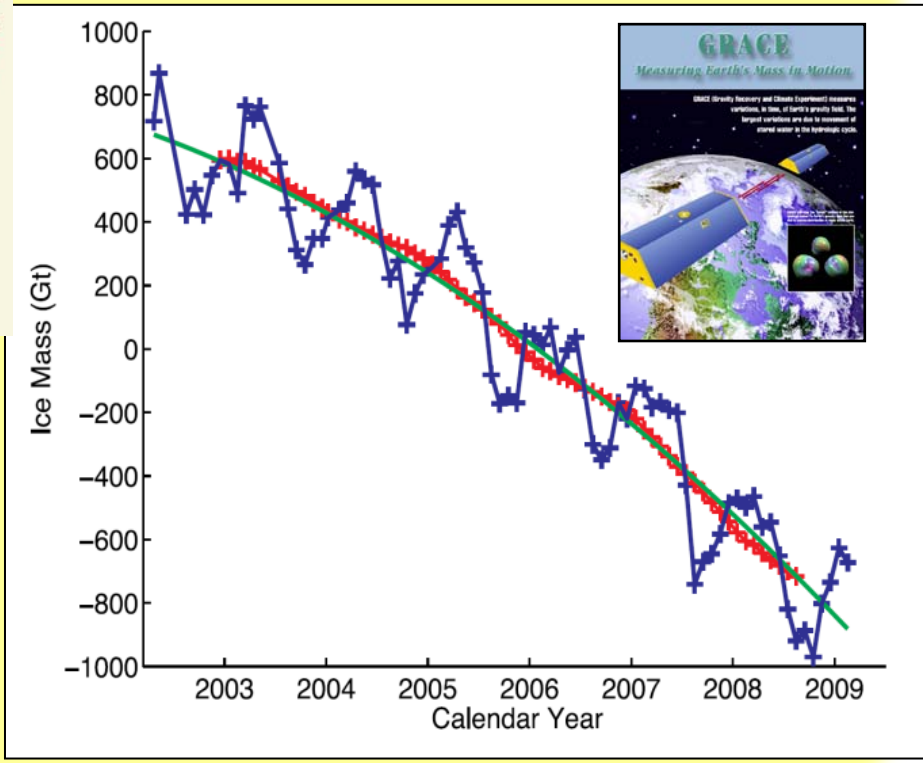
Science helps us understand the past and the present

Past



Correlation of carbon dioxide, methane, and temperature over 800,000 years (from trapped air bubbles in Vostok ice core)

Present



Changes in Mass of Greenland Ice Sheet (GRACE satellite measurements)

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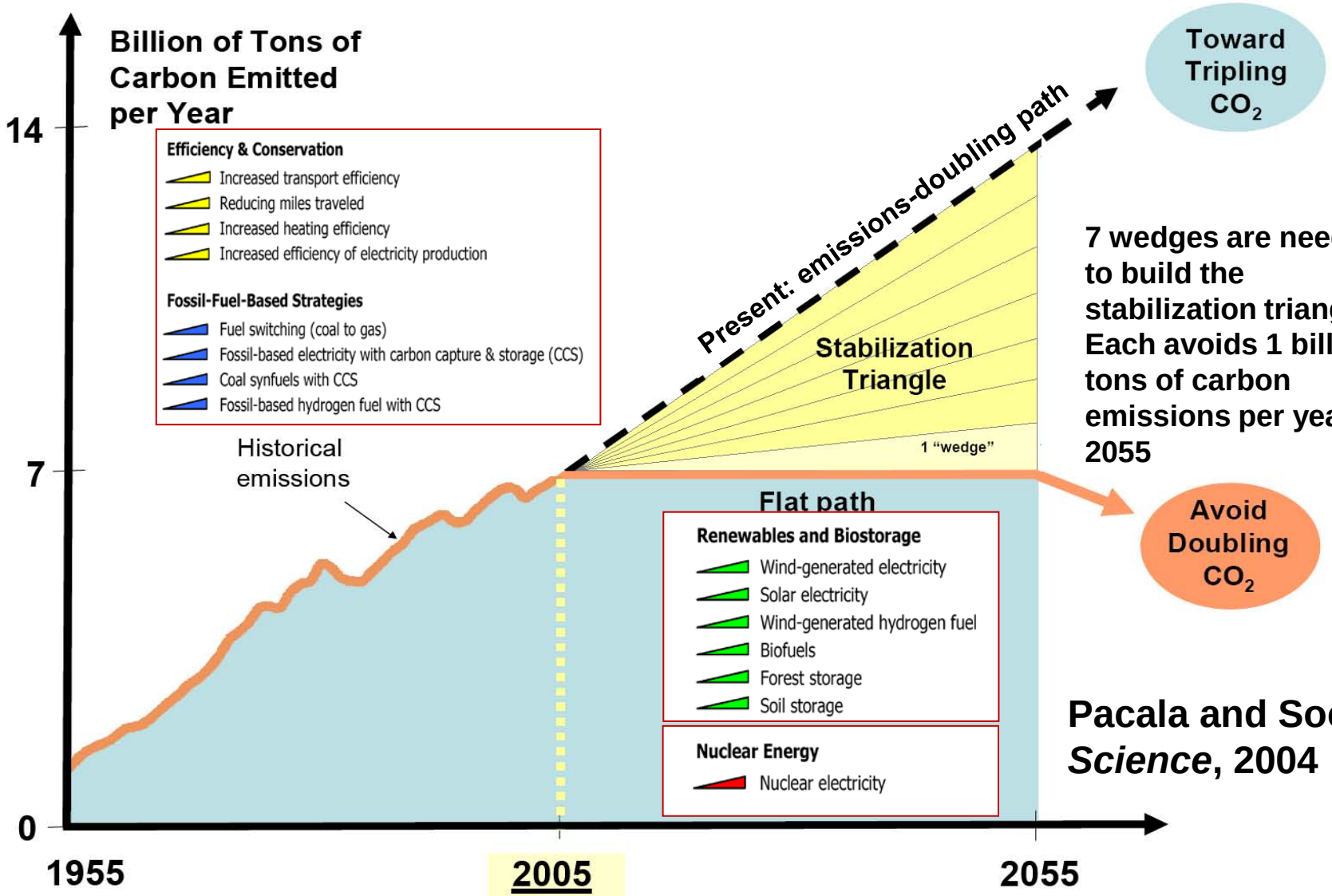
Starting point: with existing technologies, carbon emissions can be *stabilized…*



7 wedges are needed to build the stabilization triangle. Each avoids 1 billion tons of carbon emissions per year by 2055

Pacala and Socalow *Science*, 2004

Energy Facts 2010

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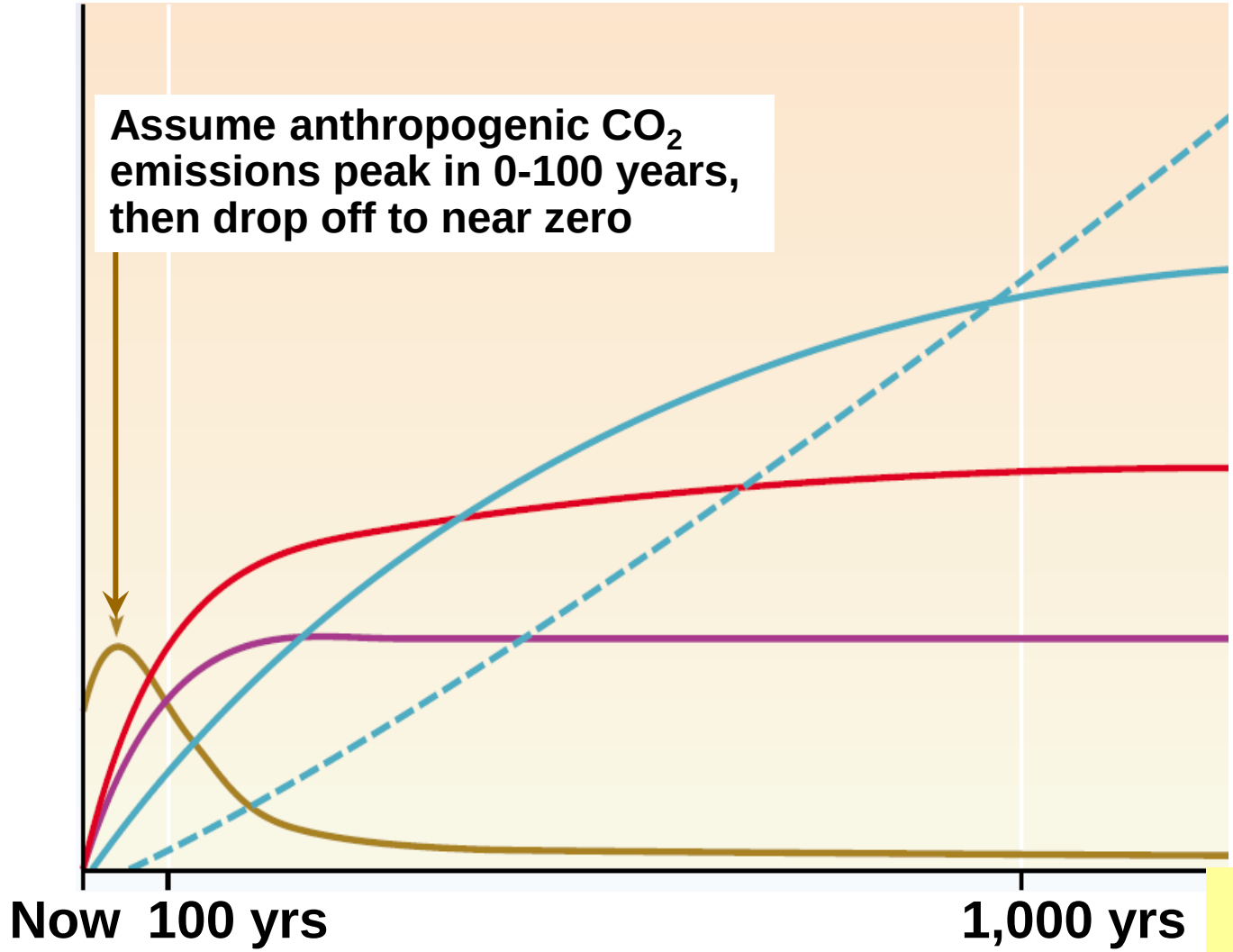
…but scientific *transformation* is needed for a long term solution



IPCC | INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

CO_2 emission rates must fall to keep CO_2 levels and temperatures stable

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Long term: if fusion is available by the second half of this century, it can be a significant player in the energy economy by 2100

- Assume ITER, DEMO, and supporting research establish the basis for fusion energy by 2050. Then

  - Conservative assumption: Note that fission grew from 1975 through 1990 at 1.2%/year of the world electric market. Then if fusion grows at < 0.9%/year of after 2050,

➔ *fusion can deliver at least 30% of the world's energy production by 2100**

** Goldston, Grisham, Hammett, IAEA 2010, "Climate Change, Nuclear Proliferation, and Fusion Energy"*

➔ fusion can also contribute to fuel-switching strategies (e,g, off-peak hydrogen production)

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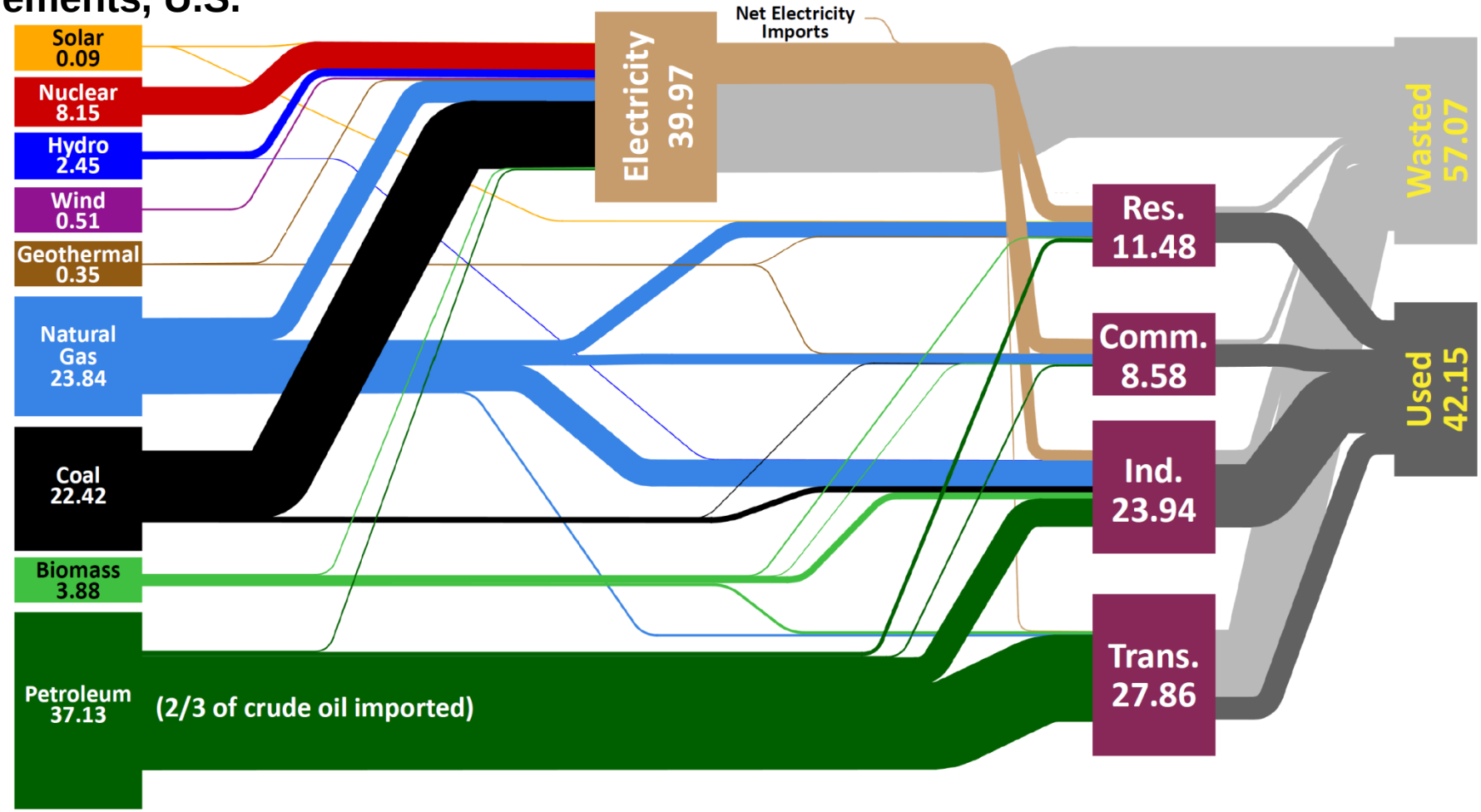
In the near term, the ***scientific transformations must take place on a broad front***

Present energy usage and strategic elements, U.S.



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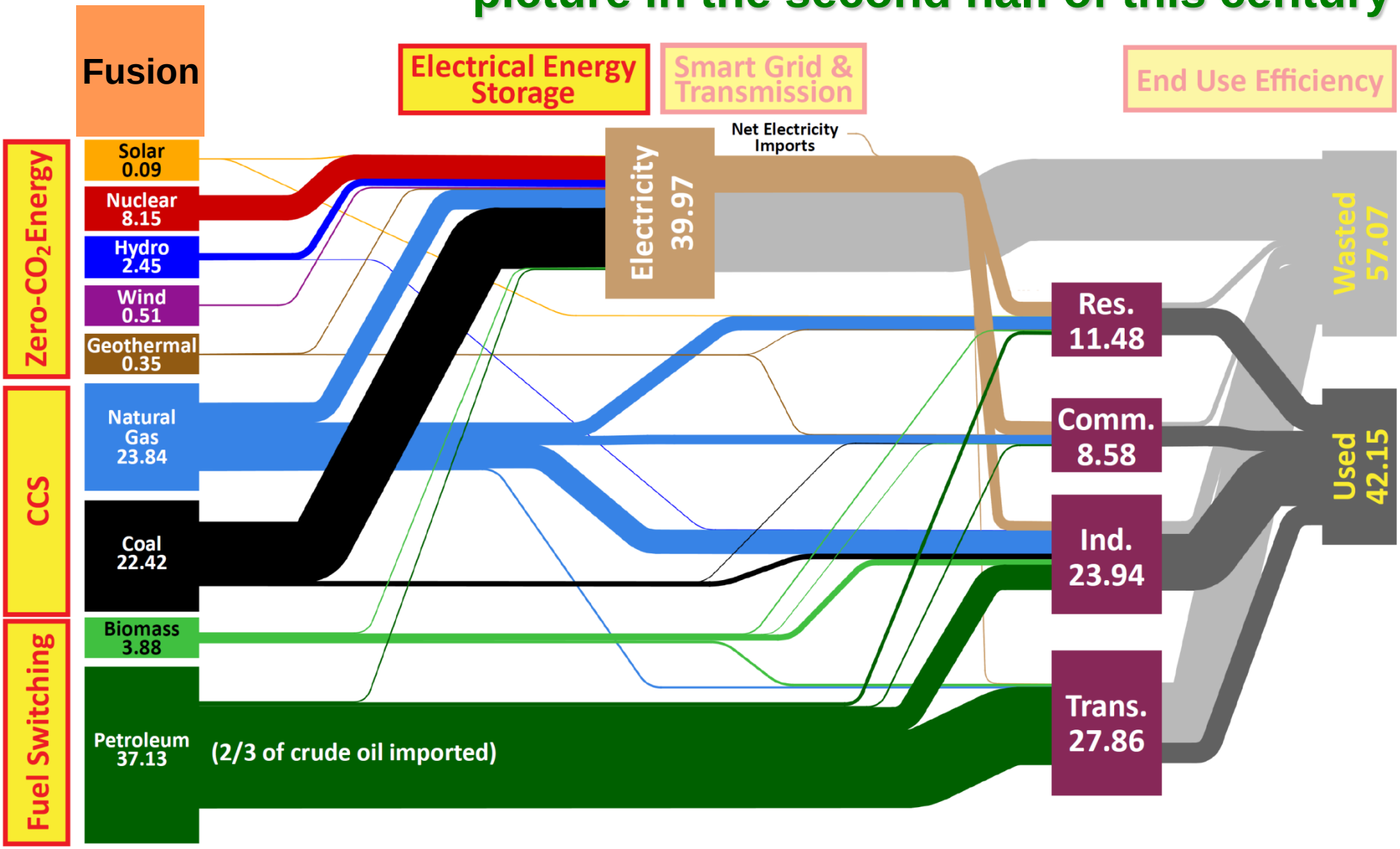
Fusion can fundamentally alter this picture in the second half of this century



➔*Every path is potentially redrawn with fusion, and its presence will impact the urgency of or redirect nearly every area of front-line research*

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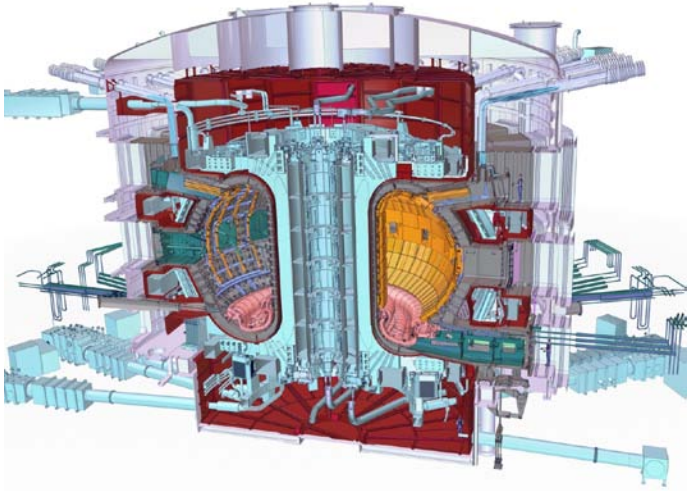
Fusion can deliver in time to have a major impact this century

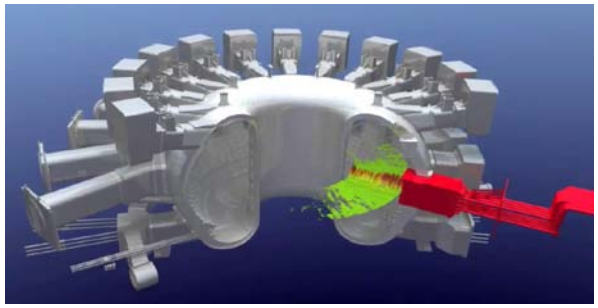
Three ingredients:

- ITER: the fundamental science of a burning plasma. ITER will establish the science of robustly and attractively controlling fusion plasmas that heat themselves

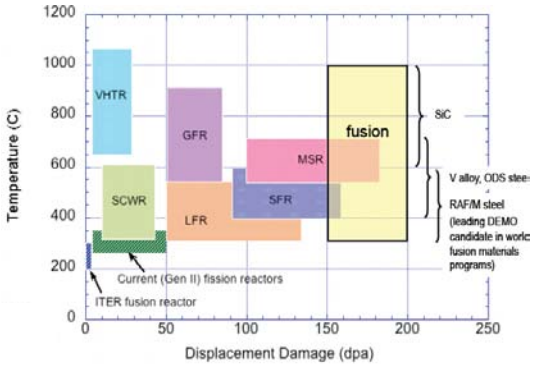
- **Validated predictive capability**: a supporting world program in experimentation and theory/simulation to
  - complement ITER and develop its operating scenarios
  - Develop the predictive science required for optimizing beyond ITER

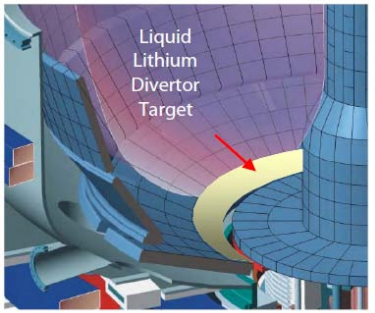
- An aggressive program in **fusion materials and the technology** to harness the fusion power from a burning plasma





Simulation of lower hybrid wave heating on ITER





NSTX

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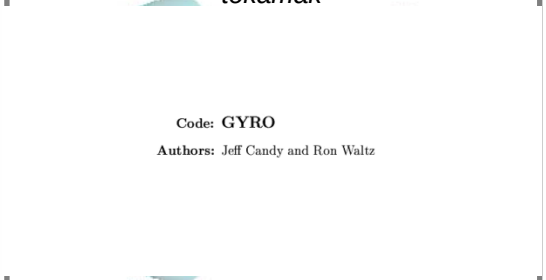
In the U.S., fusion joins the ranks of other sciences that will be called upon to solve the energy and climate challenges

Burning plasma science

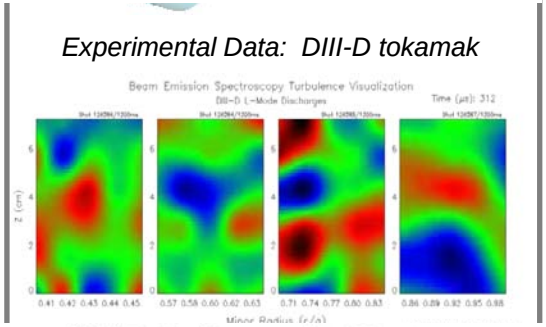
Experimental tests ⟷ **Theory**

Simulation and prediction

Simulation of turbulence: DIII-D tokamak



Experimental Data: DIII-D tokamak



A leading intellectual challenge is developing an integrated, validated predictive capability for burning plasmas

U.S. ITER Office

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Fusion can be transformative, and its future rests in *our* hands

- The well-being of all of us is intimately linked to technological transformation, whether we live in developed or developing nations

- Fusion represents a transformational science that can be part of our long-term energy and climate solutions, and can be critical in enhancing political stability

- This international meeting in Monaco is an indication of just the sort of engagement we need – fusion requires all of our talents, all of our resources, because the stakes are so high.

Thank you