DOE National Laboratory Ideas Summit

ENABLING RAPID COMMERCIALIZATION OF NUCLEAR ENERGY INNOVATIONS

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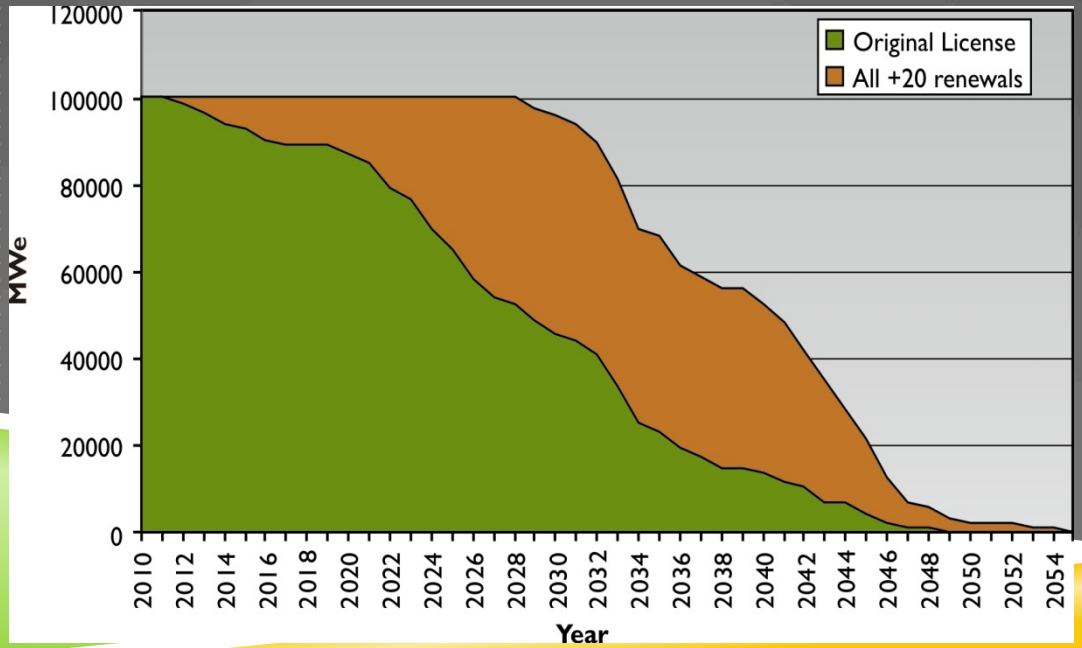
NUCLEAR ENERGY STATUS

- Currently U.S. nuclear electricity generation capacity is ~100 GWe
  - 20% of total electricity capacity
  - 64% of clean electricity capacity
- With a life extension to 60-years, if the remaining reactors operate to the end of their life, and if no new reactors are built, nuclear energy contribution to the nation's energy demand will decline rapidly after 2030.
- It takes a long time (> 20 years) and expensive testing to develop innovative systems & components into a level of commercial readiness.



NUCLEAR ENERGY PRIORITIES

- Continued reliance in nuclear energy is essential in achieving our national goals in
  - National and energy security
  - Economic prosperity and competitiveness
  - Environmental/climate change goals

- To meet the future energy challenges, we must, through innovation,
  - Extend the life of existing reactors beyond 60 years and safely manage the used fuel they discharge
  - Develop advanced nuclear energy systems with improved economics, safety, security, proliferation resistance, resource utilization and used nuclear fuel management

WHAT IS THE BIG IDEA ?

Enable the replacement and future expansion of the current US nuclear capacity by changing the RD&D paradigm for faster deployment of innovative technologies

- An integrated National RD&D framework to support the "engineering-driven, science-based approach"
- An advanced test reactor that enables demonstration of the innovative technologies and the viability of the new RD&D paradigm
- Significant emphasis on development of advanced nuclear fuels and materials
  - Also, applicable to other innovative technologies that require a long-time to develop, e.g. instrumentation and control system

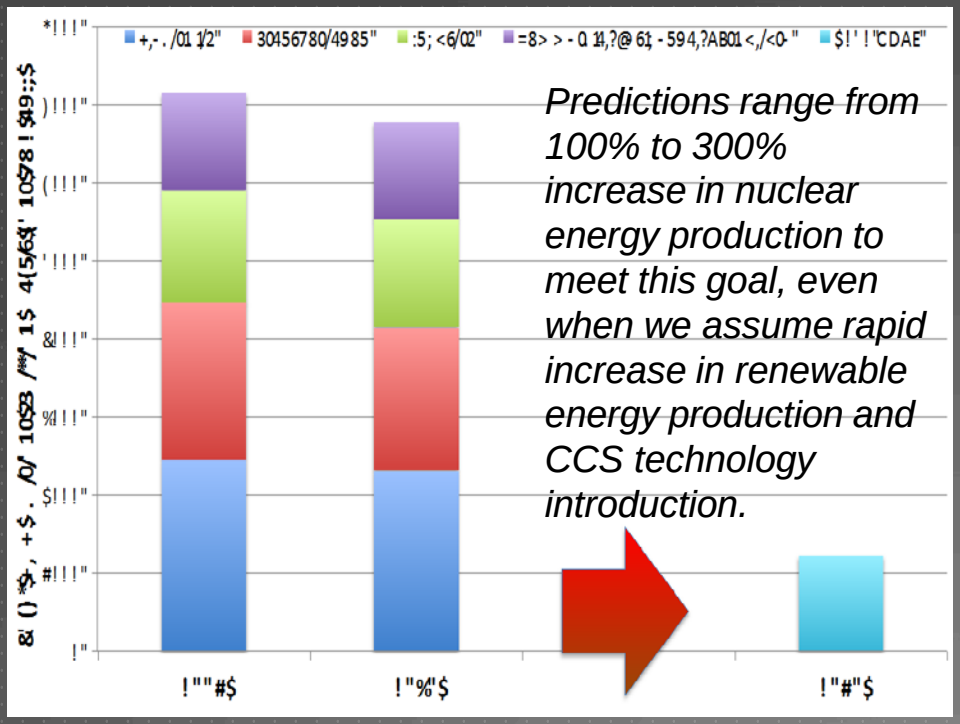
GRAND CHALLENGE: An RD&D paradigm and supporting infrastructure that can advance the TRL from concept to commercial readiness in ≤ 10 years

IMPACT

- 5 year goal: establish the integrated R&D framework to support the "engineering-driven, science-based" approach for technology
  - Focus: Advanced materials for the next-generation of LWR fuels
- 10-year goal: establish the capability to demonstrate the new paradigm, including design and licensing of an advanced reactor as the test bed.
  - Focus: Advanced fuels and materials for next generation reactors
- The advanced technologies and innovative concepts are ready for commercial deployment in the 2030's with the following attributes:
  - Electricity generation at a lower cost than currently known nuclear energy systems;
  - Adaptation to a dynamic grid with large input from renewable energy sources
  - Process heat application at competitive prices
  - Improved resource utilization and management of UNF

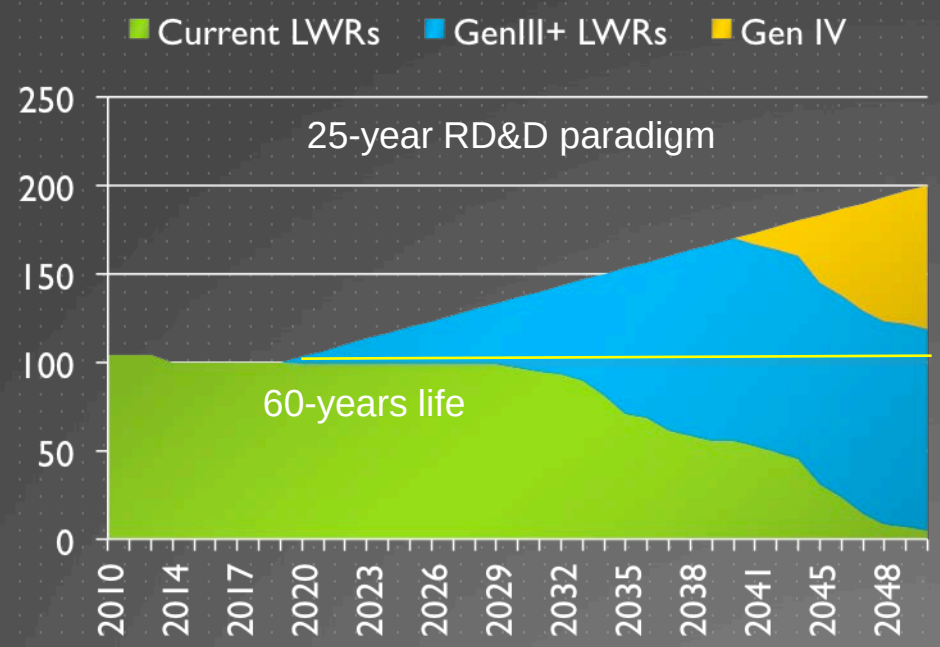
Additional side benefits to materials R&D for fusio
energy systems

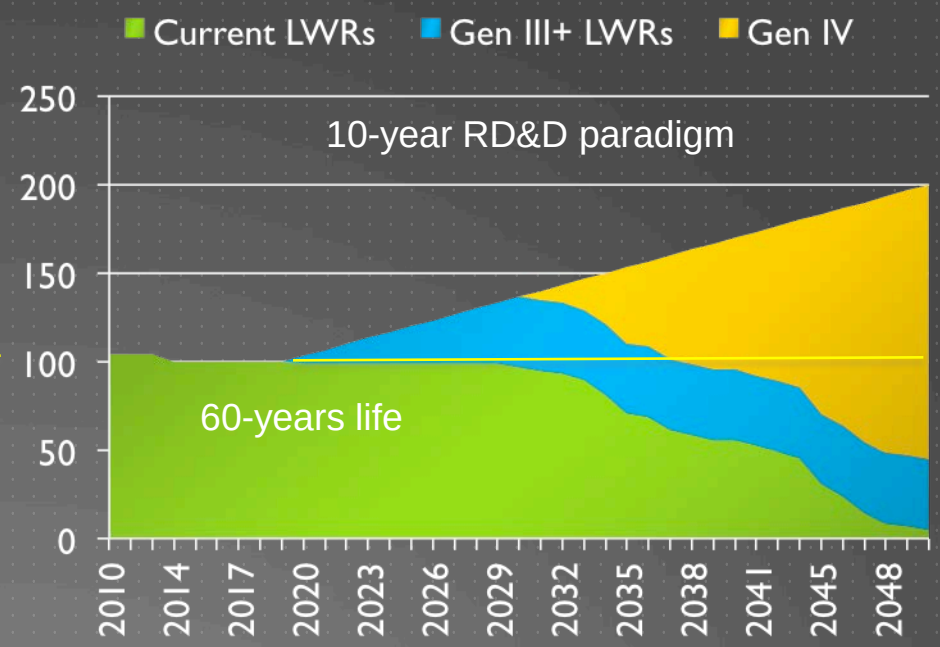
IMPACT ON CLIMATE CHANGE GOALS



- To achieve this goal, nuclear energy and renewable energy must increase considerably beyond current contributions to energy production.
- Clean energy sources must penetrate beyond just the electricity production
  - Non-electric applications of nuclear energy
- Nuclear-energy must be integrated into a grid with a large fraction of electricity from renewables

POTENTIAL PENETRATION OF ADVANCED SYSTEMS INTO THE ENERGY MARKET



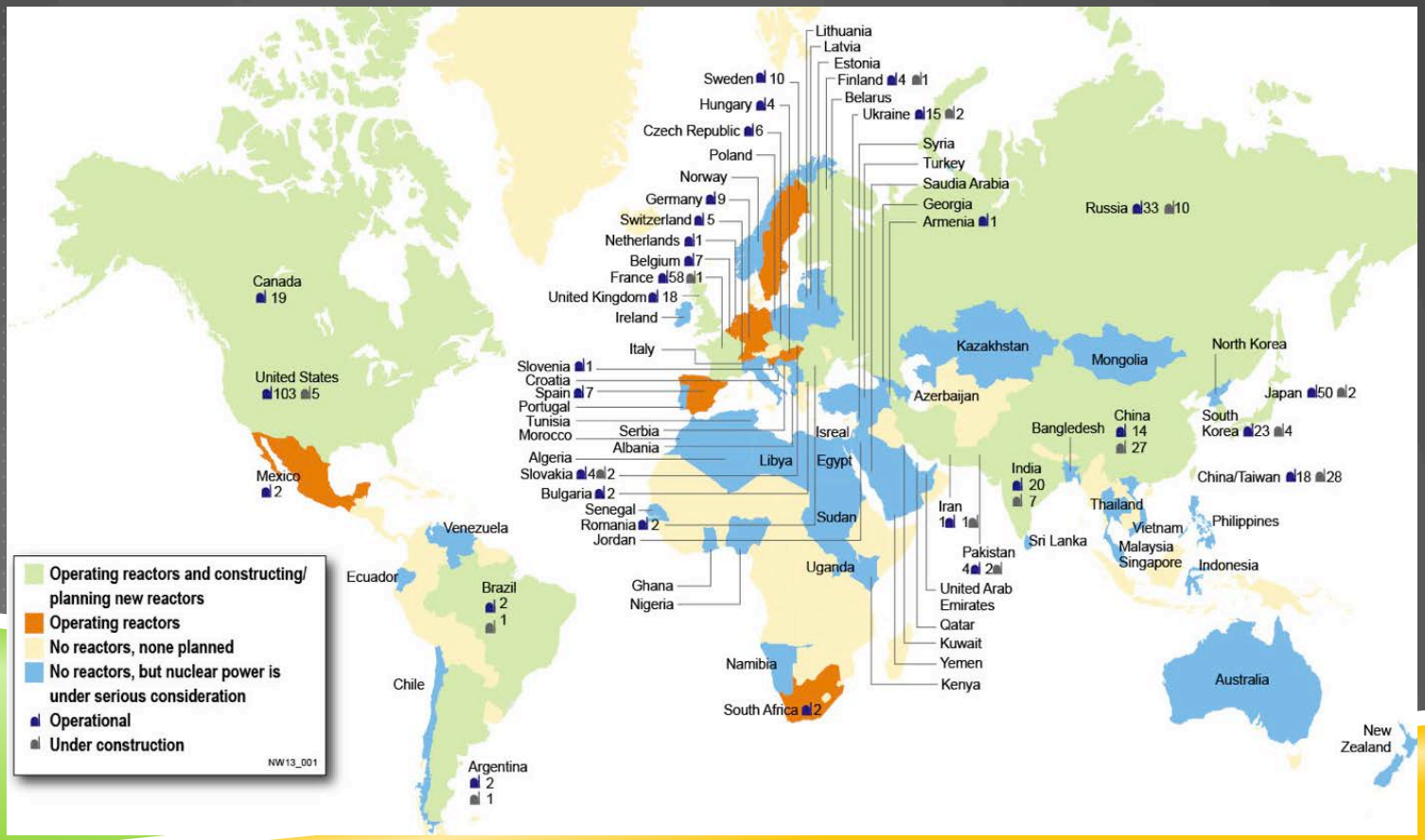


Assumption

- Nuclear energy capacity of 200 GWe by 2050 (low end of the GHG reduction studies)

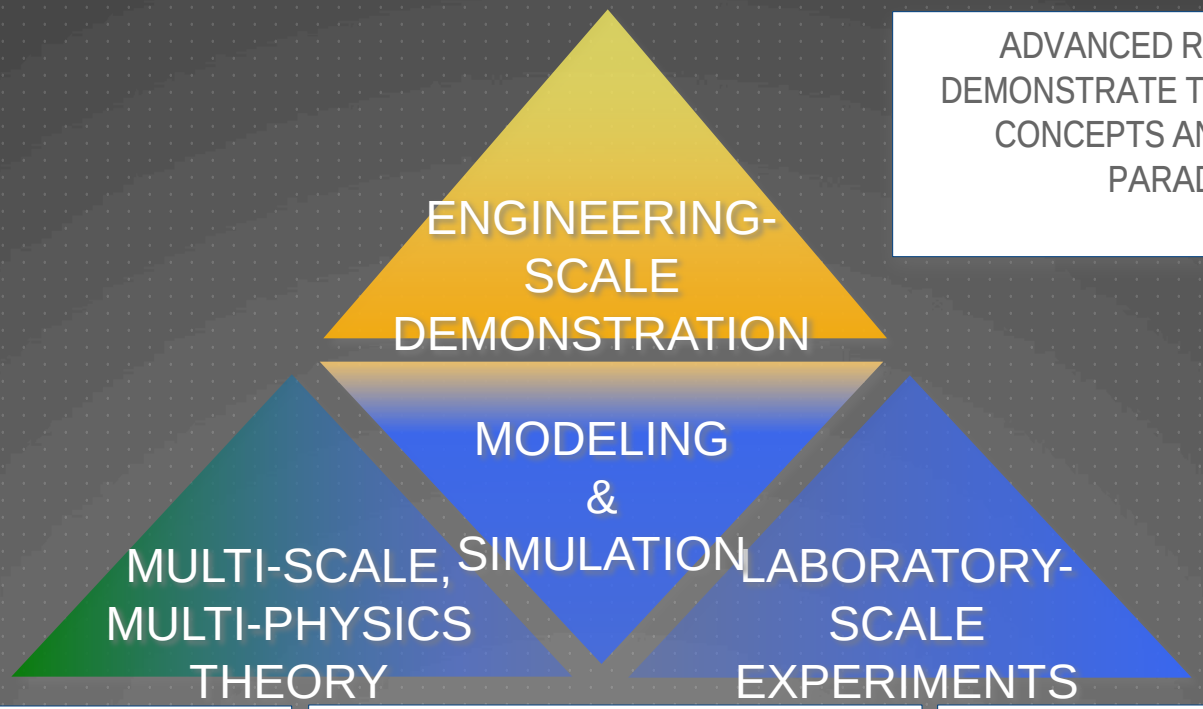
GLOBAL CONTEXT

- Demand on nuclear energy is growing globally
- The faster RD&D paradigm increases our ability to
  - Export innovative U.S. technologies
  - Provide technology leadership and influence the international nuclear energy policies



WHAT NEEDS TO BE DONE ?

ADVANCED REACTOR TO DEMONSTRATE THE INNOVATIVE CONCEPTS AND THE NEW PARADIGM

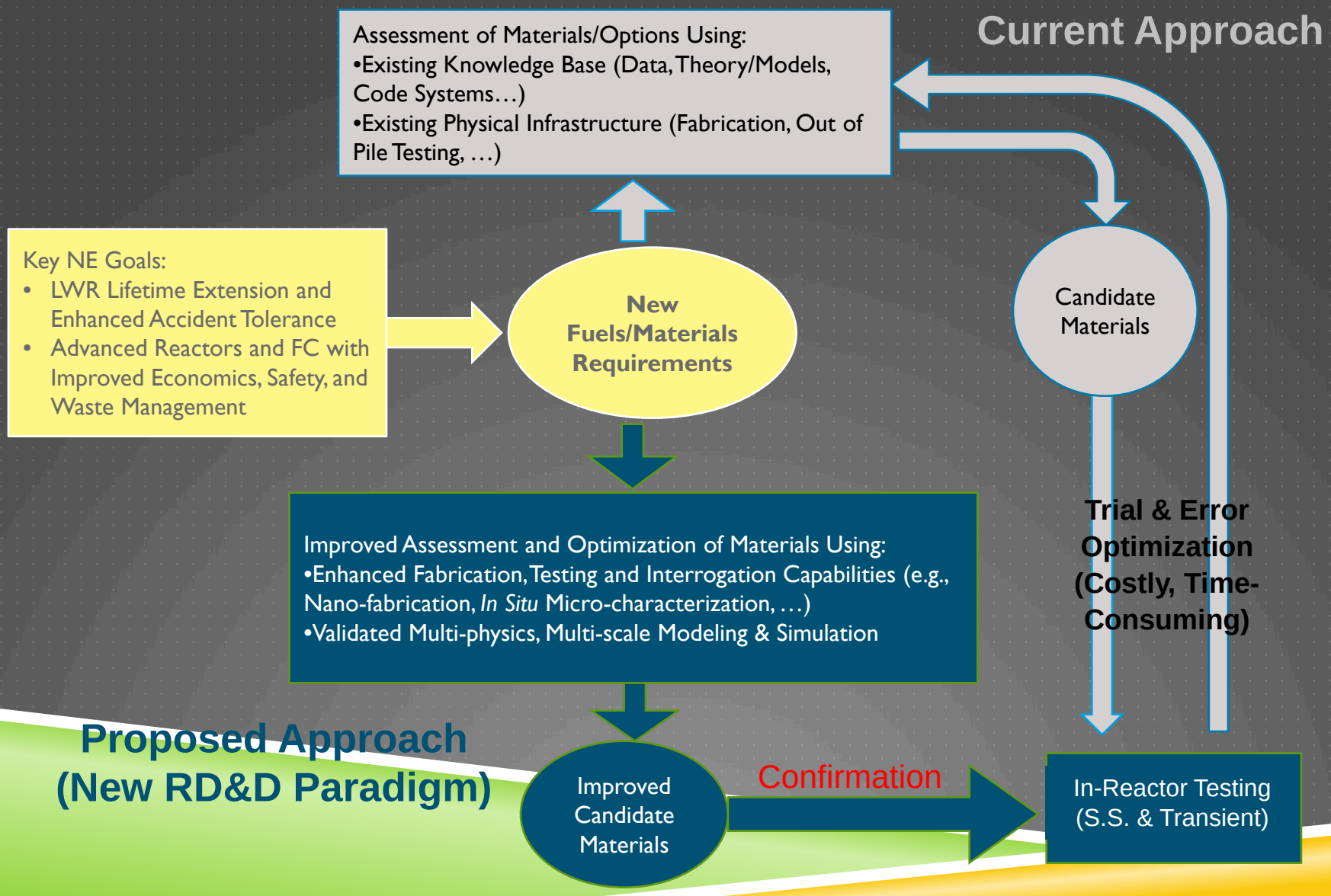


Knowledge/Data Center(s)
Easy access to data and associated knowledge at different-scales with the ability to synthesize the data for the physical model being explored.

State-of-the Art Computational Framework(s)
Testing and coupling of multi-physics, multi-scale theories to establish a predictive set of coupled tools.

Experimental User Facilities
Development, maintenance and integration of state-of-the art experimental facilities with easy access for obtaining multi-scale and multi-physics data.

ILLUSTRATION OF THE NEW PARADIGM



DOE's ROLE

The nuclear energy mission of DOE is to advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs by resolving technical, cost, safety, proliferation resistance, and security barriers through research, development, and demonstration (RD&D).

RD&D activities and infrastructure in multiple DOE offices and the respective national laboratories can be effectively integrated to support this mission

- Office of Nuclear Energy
- Office of Science (Advanced Scientific Computing and Research, Basic Energy Sciences, and Fusion Energy Sciences)
- National Nuclear Security Administration

STAKEHOLDERS/INTERFACES

The proposed RD&D paradigm will provide the maximum benefit though strong collaborations with and early engagement of

- Nuclear Industry
- Nuclear Regulatory Commission