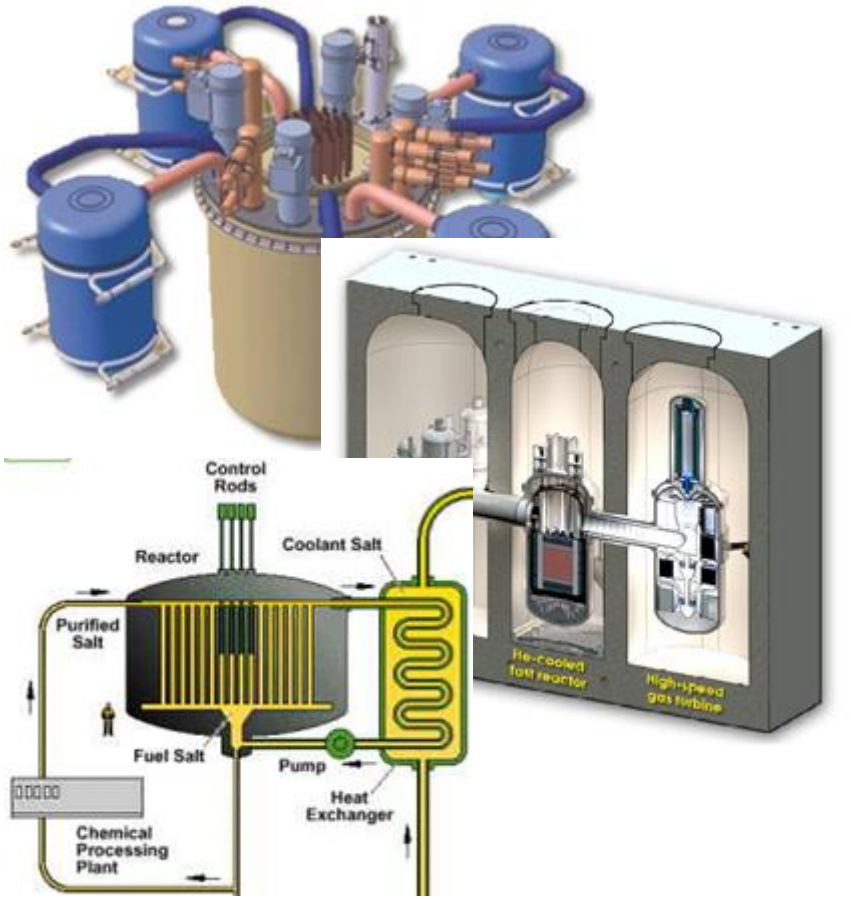
Nuclear Innovation 2050, Identifying Key Nuclear R&D Needs and Innovation Pathways



What technologies will be needed in 10 years? 30 years? 50 years?

What R&D is needed to make these technologies available?

How do we regain the ability to push innovation into application?

Nuclear Innovation Headwinds

INFRASTRUCTURE

- Unlike many other areas of innovation, nuclear technology often requires the availability of special facilities (test reactor, hot cells, test loops, etc.) and nuclear-skilled workers.
- Tests using fissile materials require appropriate facilities, trained workforce, security and licencing.
- Much of the global infrastructure was built more than 40 years ago and is shrinking steadily.

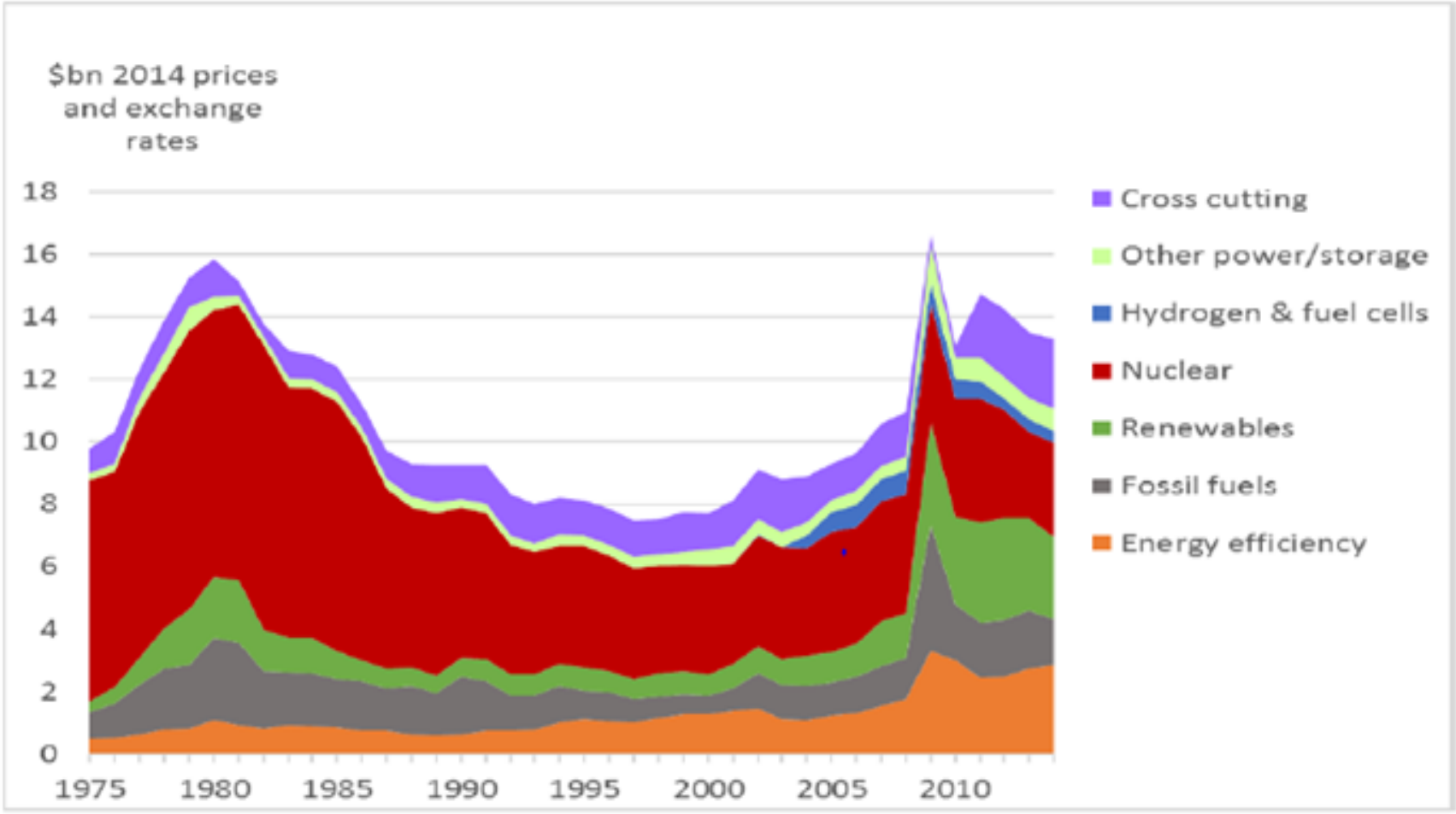
REGULATORY

- The job of today's nuclear regulatory organisations today is to assure public safety, not to promote innovation.
- Regulators in most countries will not actively participate in technology development – but will wait for the finished technology to be presented for approval.
- Regulators are often perceived by researchers and industry as a barrier to innovation.

COST

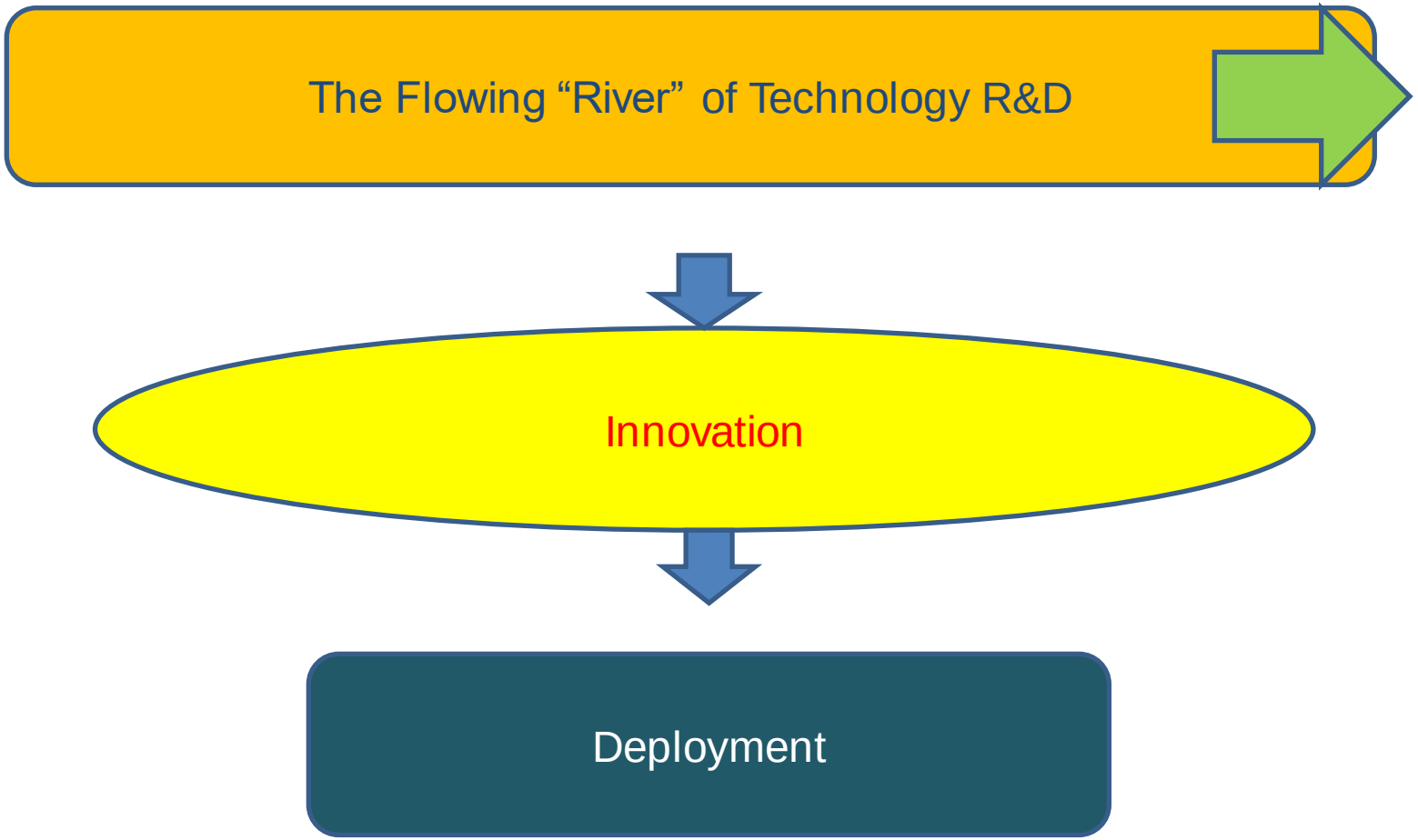
- Nuclear technology research budgets have been under pressure in most countries for the last decade.
- Nuclear technology often requires an order-of-magnitude increase in funding to transition between research and engineering-scale demonstration.
- The cost and risk of nuclear technology innovation has become prohibitive in many countries.

R&D Public BUDGETS/SCOPES



Source: Energy Technology RD&D, IEA (2015).

NI2050 CHALLENGE:
How to Move from Research to Innovation



Nuclear Innovation 2050

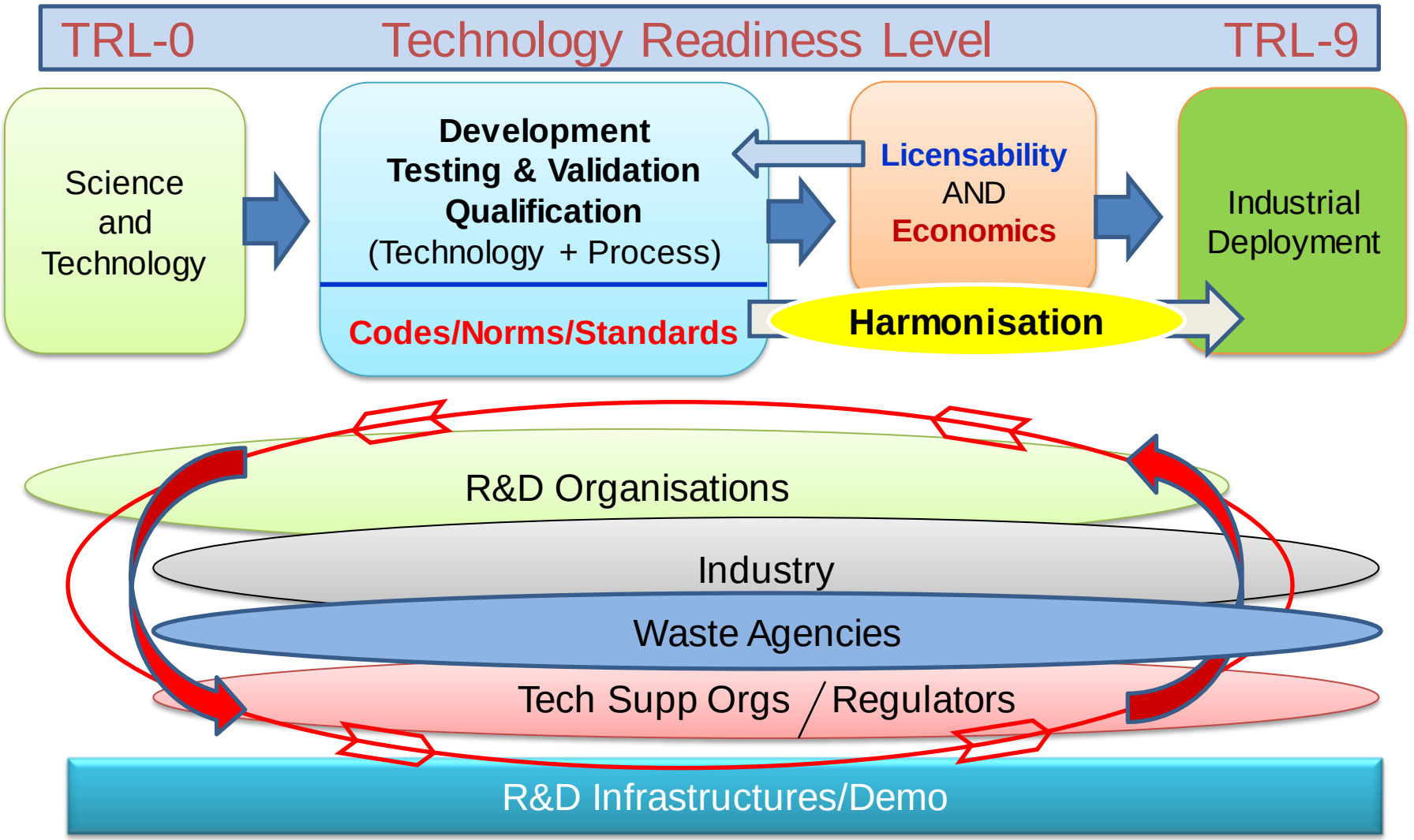
Broad NEA Initiative

Building a co-operative framework enabling innovative fit-for-purpose nuclear fission technologies

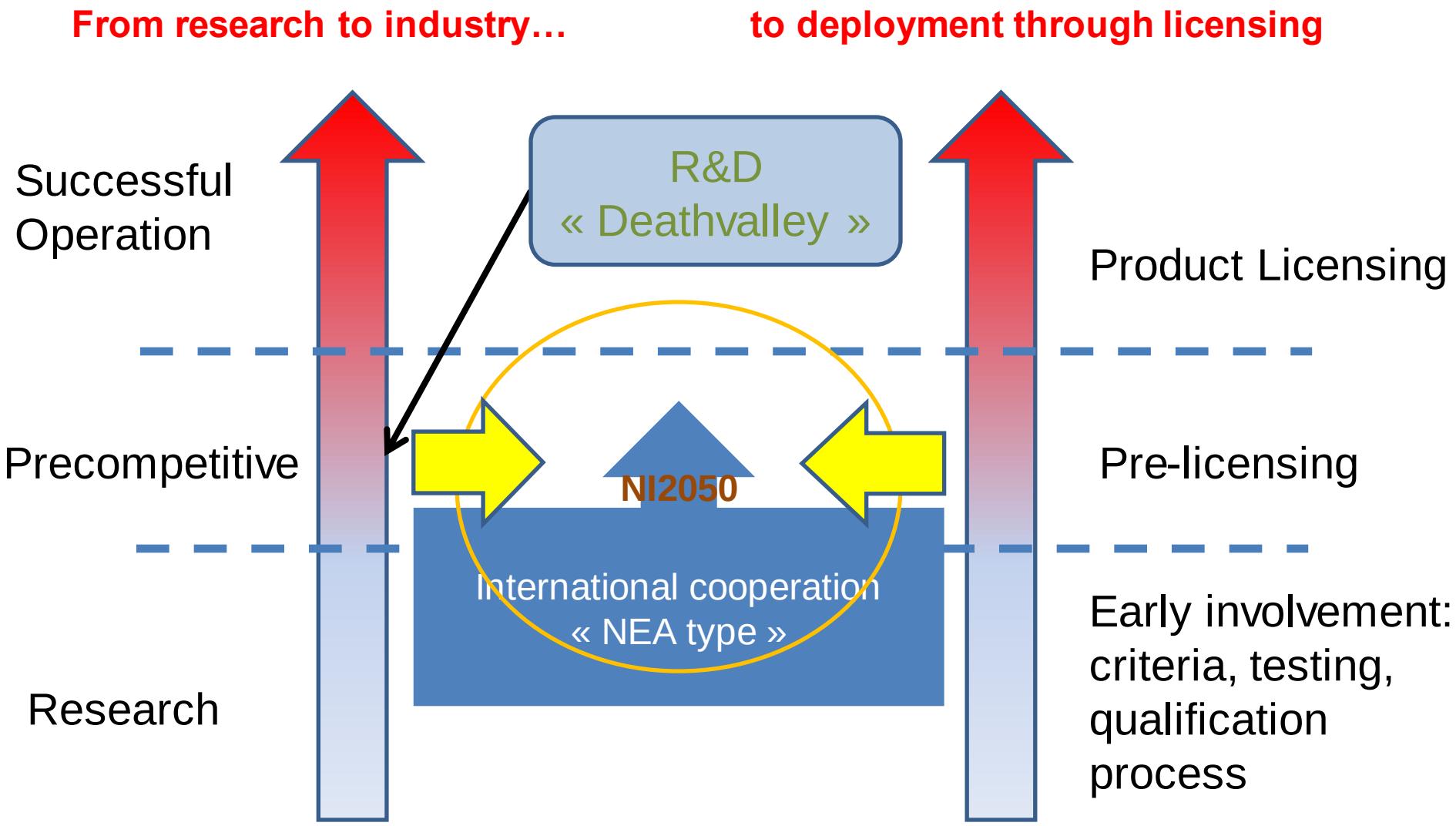
Aim

to accelerate R&D and market deployment
of innovative nuclear fission technologies
to contribute to a sustainable energy future

NI2050 CONCEPT:
From Science to Market Deployment



Technology and Licensing Readiness



NI2050 "Templates" Topics (January 2018)

Target Area/TOPIC	Leaders	Groups Engaged
Accident Tolerant and Advanced Fuels	K. Pasamehmetoglu, INL N. Chauvin, CEA	NSC (EGATFL), CSNI (WGFS)
Severe Accident Knowledge and Management	G. Bruna/D Jacquemain, IRSN	CSNI (SAREF, WGAMA) ETSON, NUGENIA
Passive Safety Systems	G. Bruna/JM Evrard, IRSN	CSNI (WGAMA) ETSON
LTO Gen II 80 Years: Ageing Management	A. Al Mazouzi, EDF	CSNI (WIAGE) NUGENIA
Advanced Materials (Gen IV)	L. Malerba, SCKCEN	NSC (WPFC, WPMM), EERA JPNM, GIF
Advanced Components (Gen IV)	H. Kamide, JAEA	GIF, CSNI/CNRA (GSAR/WGRNR)
Fuel Cycle Chemistry/Recycling (P&T)	H. Ait Abderrahim, SCKCEN	NSC (WPFC), CSNI (WGFCS)
Heat Production and Cogeneration	D. Hittner, NC2I	PRIME/GEMINI (NC2I, NGNP, JAEA, KAERI)
Modelling and Simulation	T. Valentine, ORNL	NSC (WPMM, EGMPEBV)
Measures and Instrumentation	G. Bignan, CEA	ANIMMA, NSC Wkshp
Infrastructures and Demos	All	NSC, CSNI (ia TAREF), DB (RTFDB)

Additional Template by RWMC

At its recent meeting on 21 March, the RWMC Bureau agreed to submit to RWMC a proposal for an additional template:

« R&D Cooperative Programme in support of a Nuclear Reactor Dismantling Demonstratror »

Lead drafter: M Pieraccini (who chaired the NI2050 Expert Group Meeting on Decomm and Waste in 2016)

Having a topic related to decommissioning and waste management is welcomed in the frame of NI2050 and supported by the NI2050 Advisory Panel (of which the RWMC Chair is member)

To be noted that two other proposals related to decommissioning and waste management were submitted by Russia (decommissioning of graphite production reactors in Seversk) and Japan (Robotics in support of decommissioning) in the frame of NEST – and the secretariat is reflecting on their possible interaction.

Beyond these, there are initial discussion to have a project under NI2050 to foster the interaction between all stakeholders (ia industry, regulators, waste agencies) to build common approaches for the qualification and licensing of long term waste management facilities, including deep geological repositories.

NI2050 "Templates" Topics (January 2018)

Target Area/TOPIC	Leaders	Groups Engaged
Accident T		
Severe		
Pas		
LTO C		
Advar		NM, GIF
Advanc		R)
Fuel Cycle		
Heat Pro		AEA,
Mod		
Measu		
Infras		DB)

OECD Nuclear Energy Agency NEA

NI2050 TOOL: Template

- **1. Justification of the selection**
  Based on a list of selection criteria, explain why this topic is an opportunity for innovation
- **2. The issue (Challenge/Opportunity) to tackle and objectives to reach**
  Explain what are the problems to be solved and the associated objectives to reach.
- **3. What is done/exist already, who is doing what, what are the means (resources and infrastructures), what are the bottlenecks, why does it not go faster…**
  In most cases, R&D and/or demonstration/validation/qualification programmes and infrastructures already exist and can be briefly described. The reason why more is necessary, identifying in particular difficulties, delays and bottlenecks, justifying the inclusion of the topic in NI2050, should be explained.
- **4. What can be done to improve/accelerate (ia through cooperation)**
  Explain conceptually how to go beyond what is done under 3, what are the game changers to overcome difficulties, delays, bottlenecks, to improve and accelerate R&D and market deployment.
- **5. Action plan and necessary means (resources and infrastructures)**
  Provide an Plan of Actions (scope, sequence and timeline) to implement the concepts described in 4. This should allow the extraction of concrete projects, with definition of necessary means and infrastructures for implementation.

NI2050 Global Process/Timeline

1. **2015+:** Review for State of Play: NEA/IEA Technology Roadmap, NEA and IEA Surveys.
   Done – outcome: Graphs on R&D Budgets and Country Profiles
2. **2016+:** Development of Concepts and Selection of Priority areas and target Topics with potential for innovation (Advisory Panel and Expert Meetings).
   Done – outcome: 9 priority target topics
3. **2017+:** Drafting of « templates/roadmaps » for each selected topic (Adv Panel)
   Done - most finalised – deadline for all was May 2018

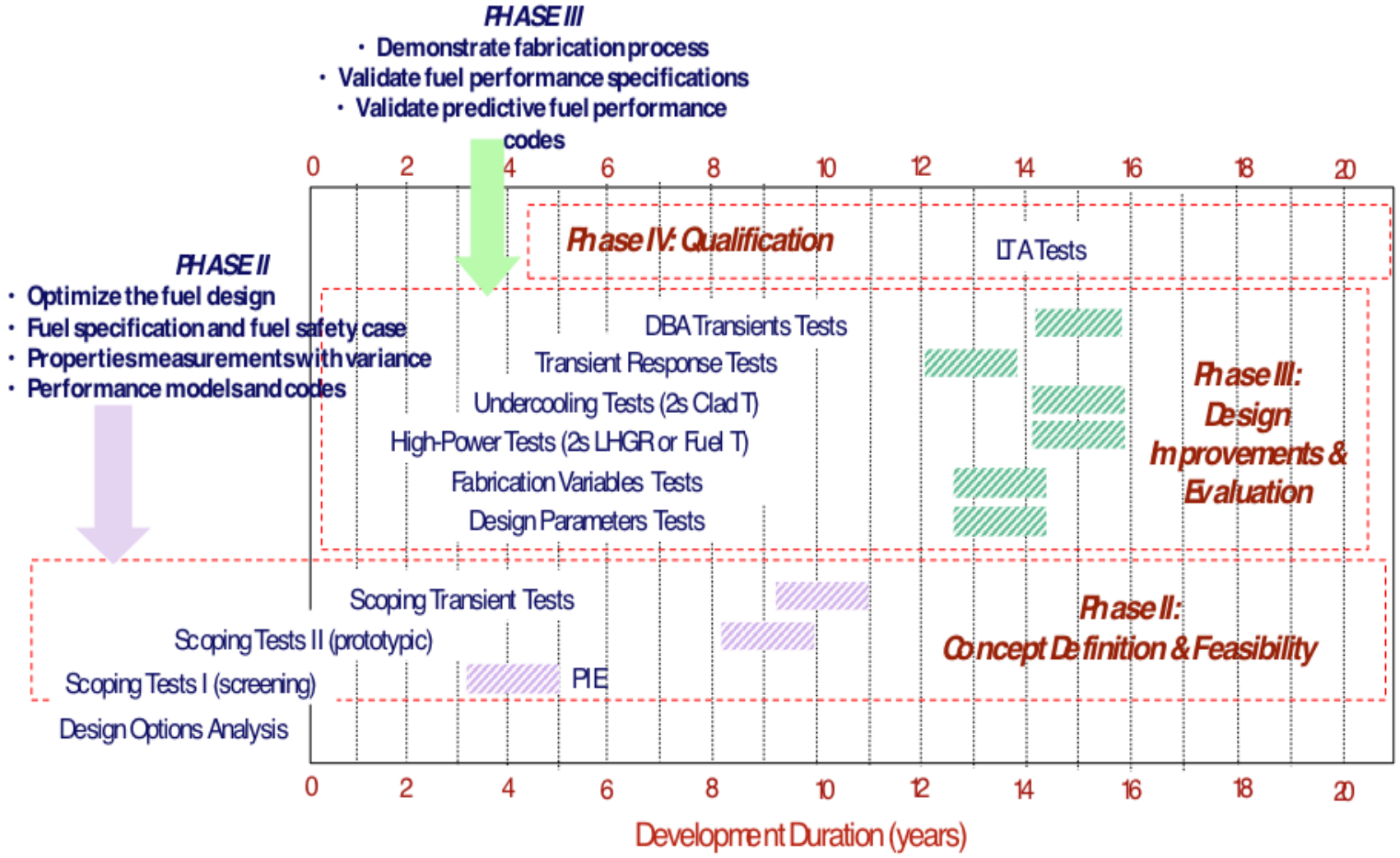
   POW 2015-2016

   DRAFT REPORT (2nd half 2018) - TRANSITION TO NEXT PHASE

   POW 2017-2018

4. **2018+:** Initiate involvement of all stakeholders, beyond science: industry and regulators, to draft detailed Implementation Programmes and Mgmt Structure
   Already started – Fuels and Materials; Heat and Cogeneration…
5. **2019+:** Discuss these Implementation Plans with Policy Makers (Member Countries and Industry) for decision on ways and means (ia financing)

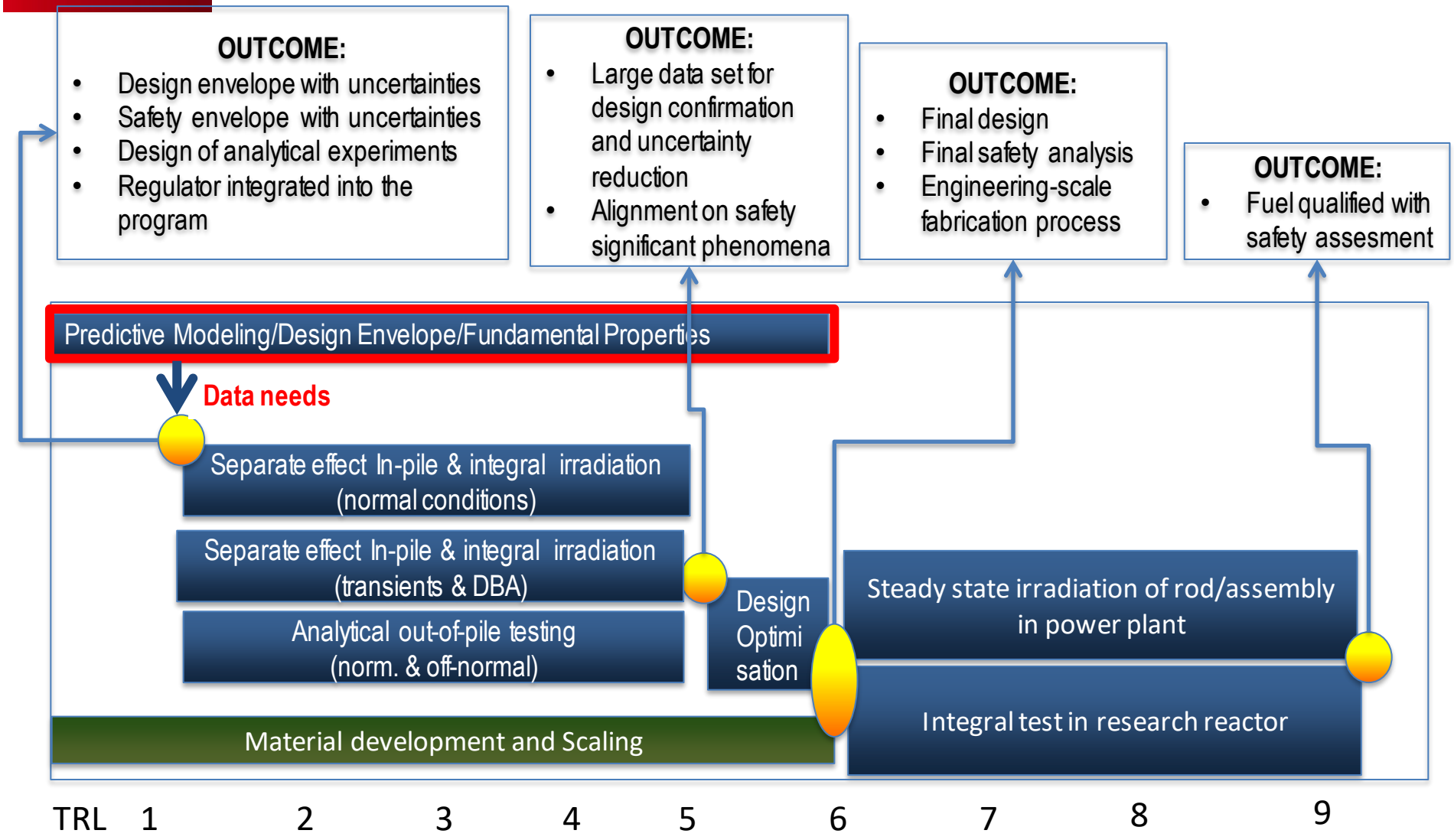
TRADITIONAL QUALIFICATION APPROACH



Acceleration means for Fuel

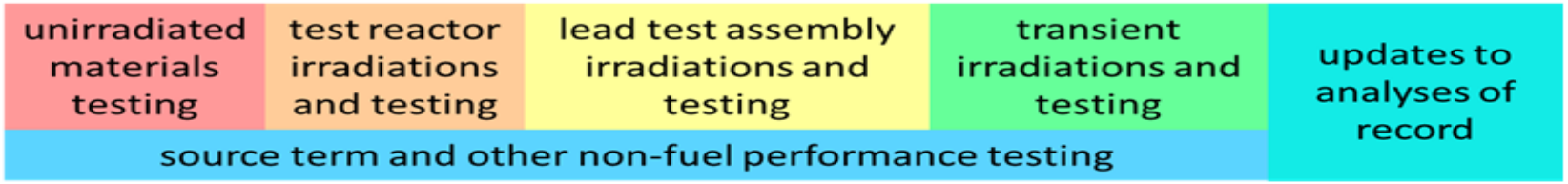
- The creation of an enhanced, robust qualification process
- Bringing the key stakeholders together to enable success
- Taking lessons learned from previous experience and enabling best practice
- Enabling tasks to be carried out in parallel through the programme
- Linking modelling with experimental work to enable an effective testing programme
- Recognising the different types of code and the different maturity levels for each
- Defining the right experiments for the best irradiation programme

NOTIONAL NEW PARADIGM

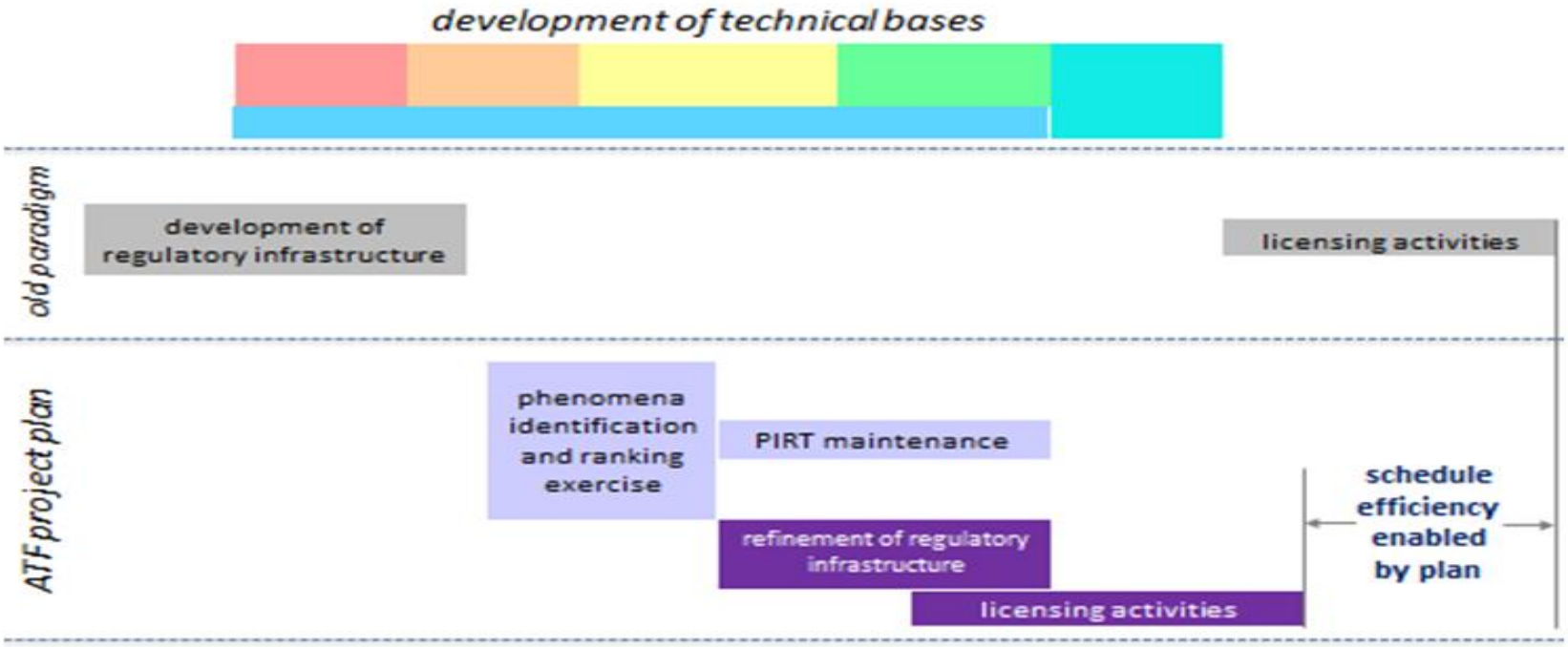


NRC views on acceleration

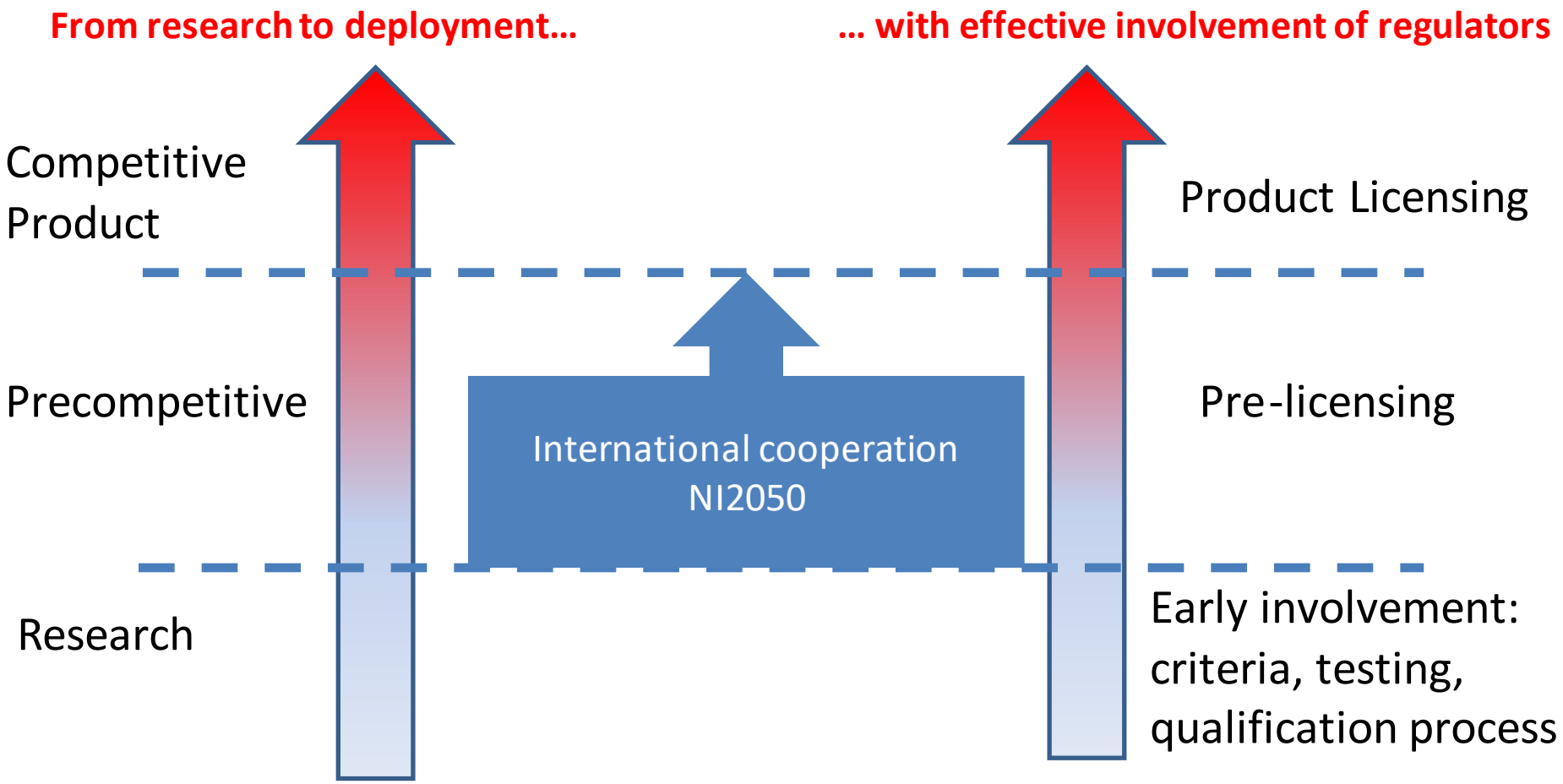
New Fuel technical basis development (NRC view):



Innovative ideas for improved fuel licensing approach (NRC view):



TECHNOLOGY AND LICENSING READINESS



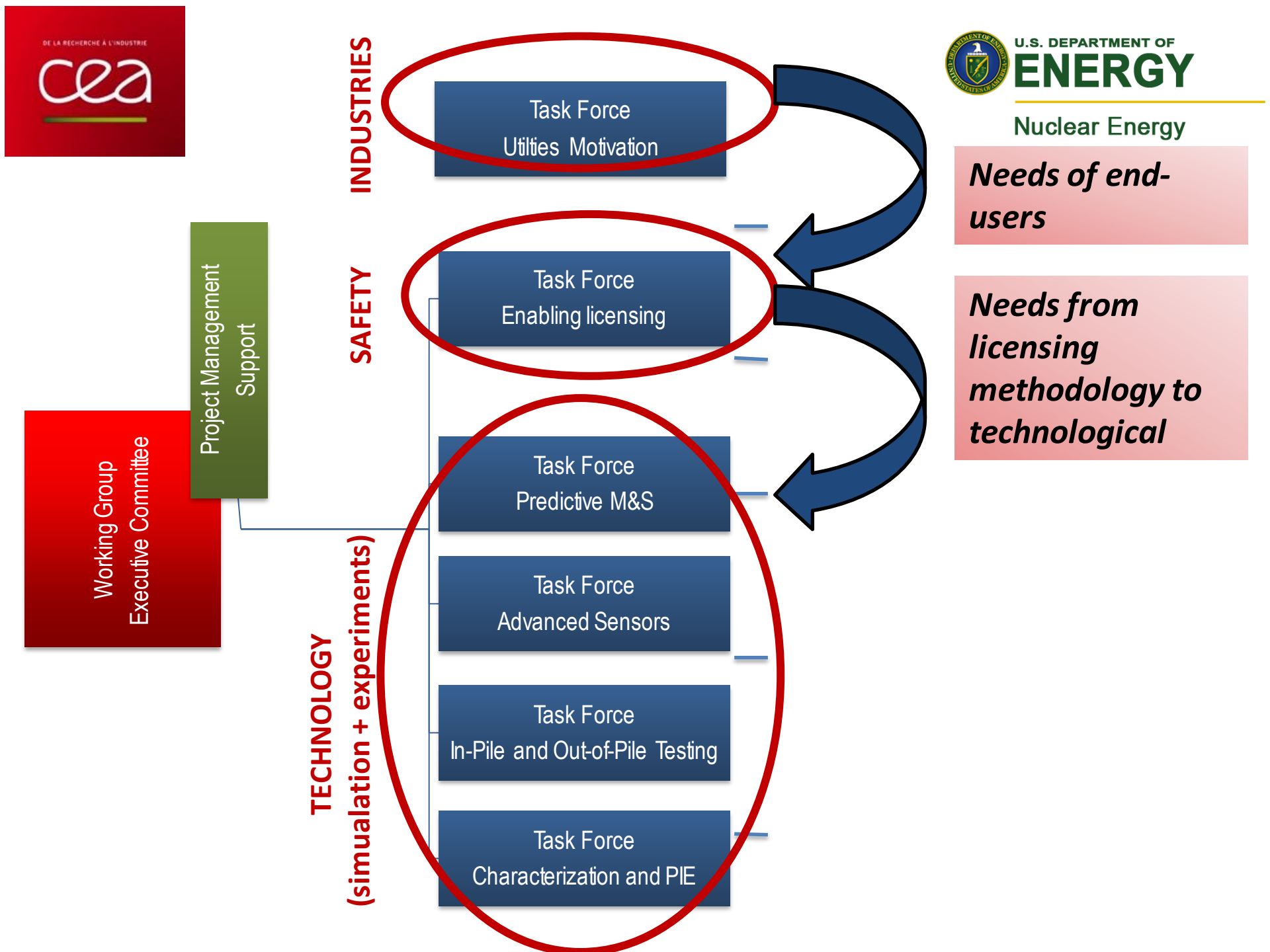
Necessary means

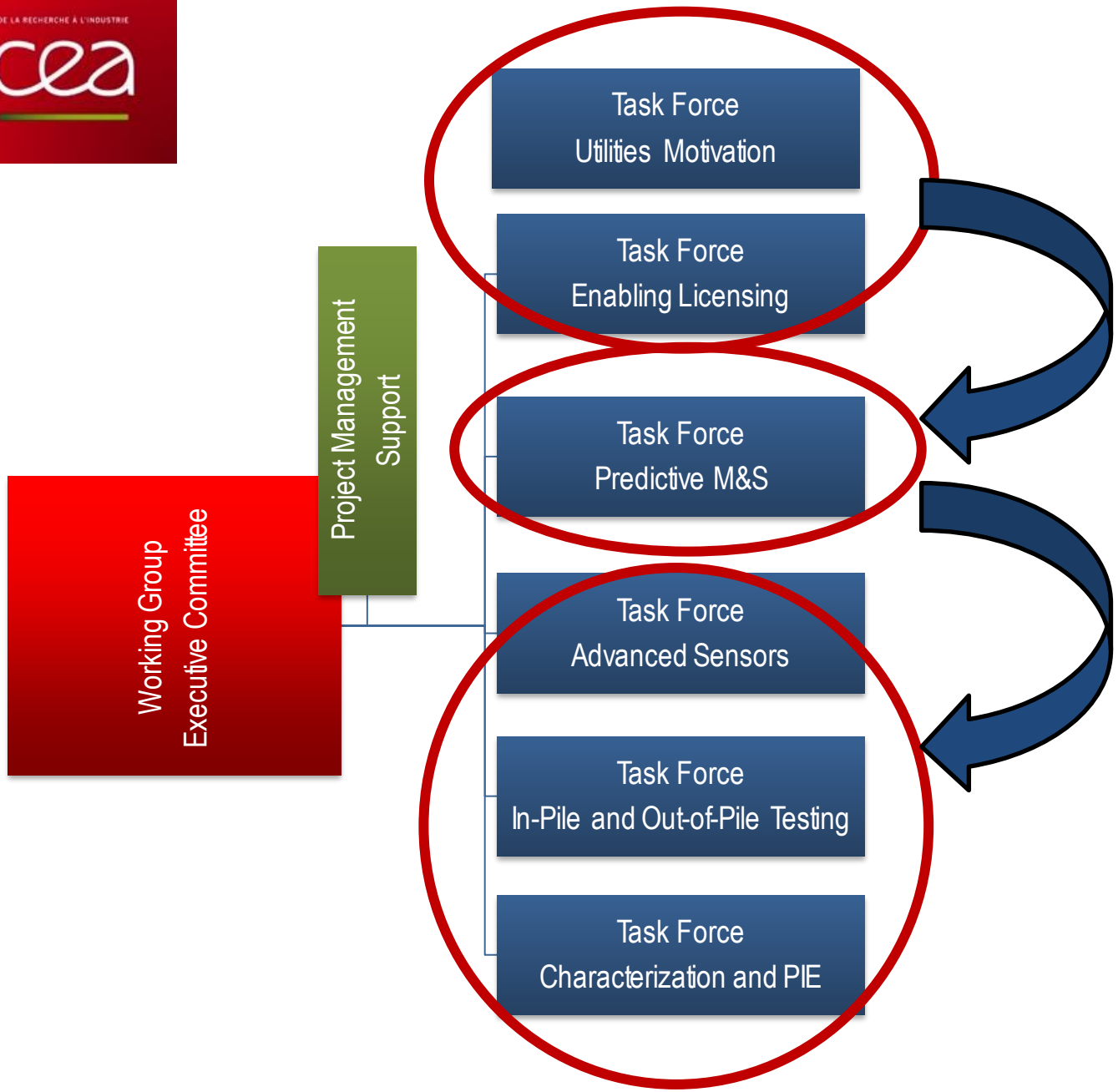
- Working group should be constituted with :
  - R&D experts on fuel, materials, simulation, irradiation design
  - Industries/stakeholders (power plants, industrial fabrication facilities)
  - safety authorities /TSO: experts on safety evaluation and responsible of safety requirements and rules

- High level execution plan with a detailed collaboration framework will be develop. The execution plan can be broken to sub-projects with expert groups.

- In defining the scope, we must be careful in not focusing in one specific fuel/clad design.

- 1 or 2 applications needed.

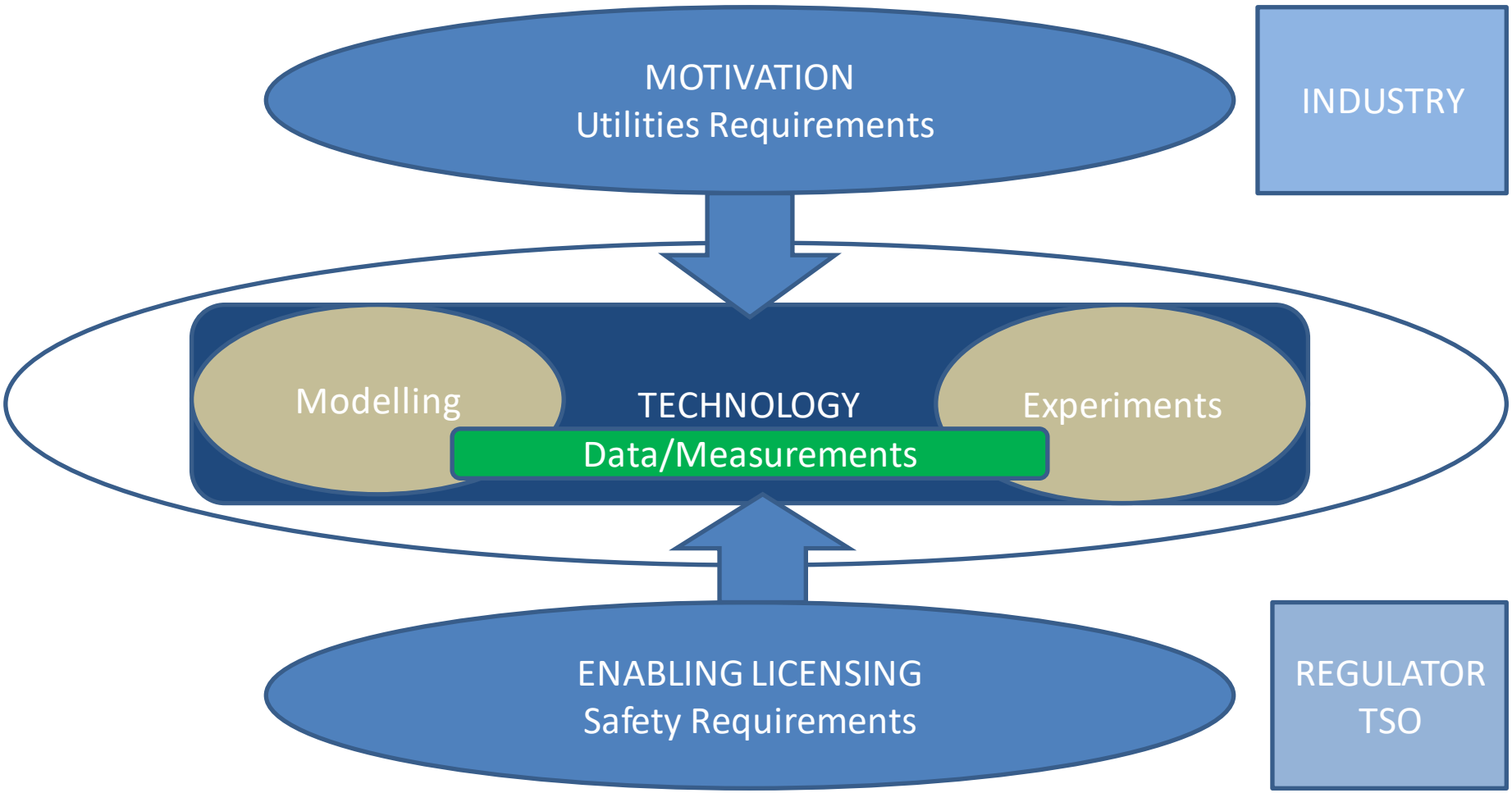

INDUSTRIES
Task Force
Utilties Motivation
SAFETY
Task Force
Enabling licensing
Project Management
Support
Working Group
Executive Committee
Task Force
Predictive M&S
Task Force
Advanced Sensors
Task Force
In-Pile and Out-of-Pile Testing
Task Force
Characterization and PIE
TECHNOLOGY
(simulation + experiments)
U.S. DEPARTMENT OF
ENERGY
Nuclear Energy
Needs of end-users
Needs from licensing methodology to technological



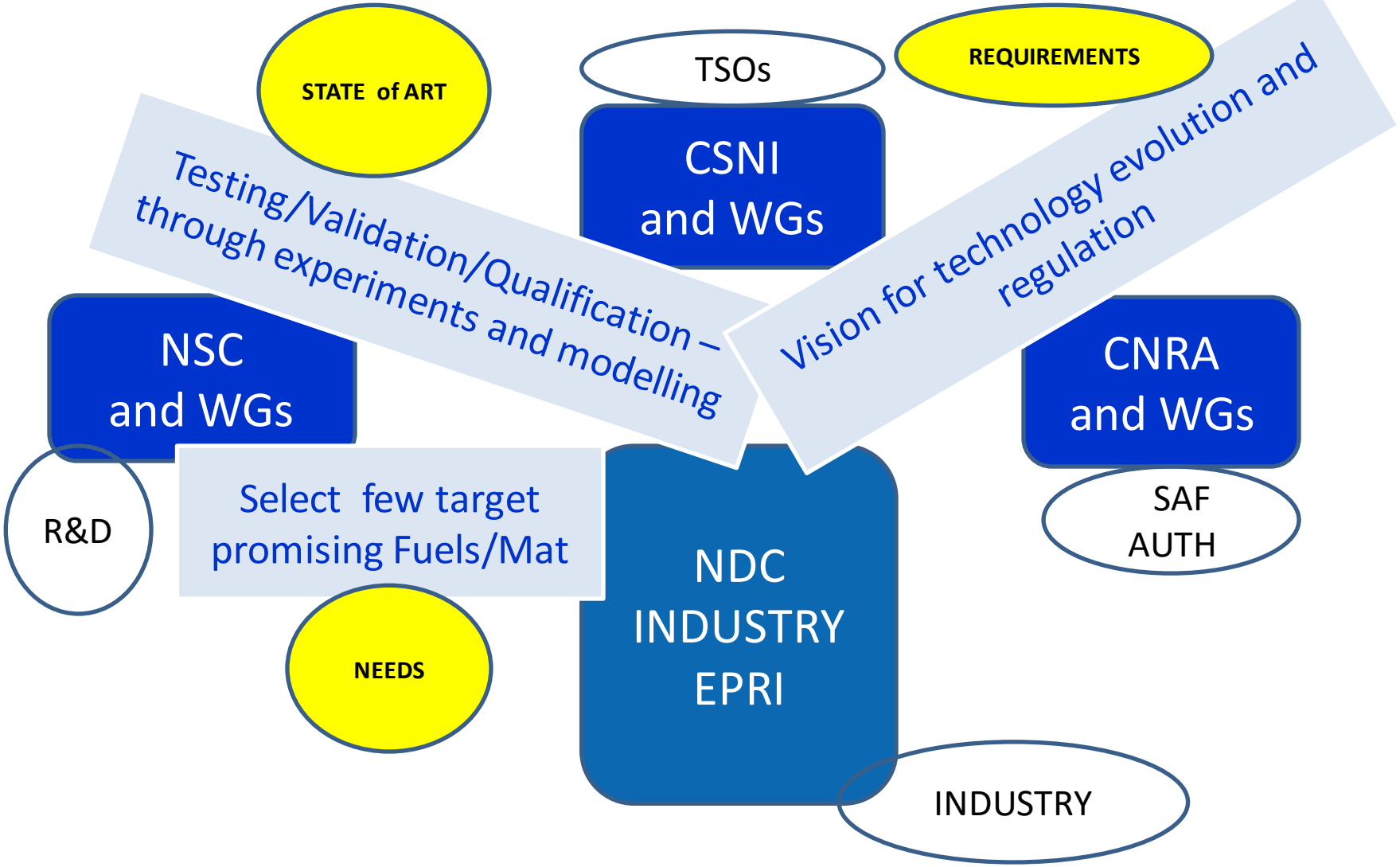
Needs for codes

Needs for experimental programme

Structure


MOTIVATION
Utilities Requirements
INDUSTRY
Modelling
TECHNOLOGY
Experiments
Data/Measurements
ENABLING LICENSING
Safety Requirements
REGULATOR
TSO

« NI2050 Fuels/Mat » and existing NEA Groups



NI2050 NEXT STEPS

EXAMPLE Advanced Fuels and Materials:

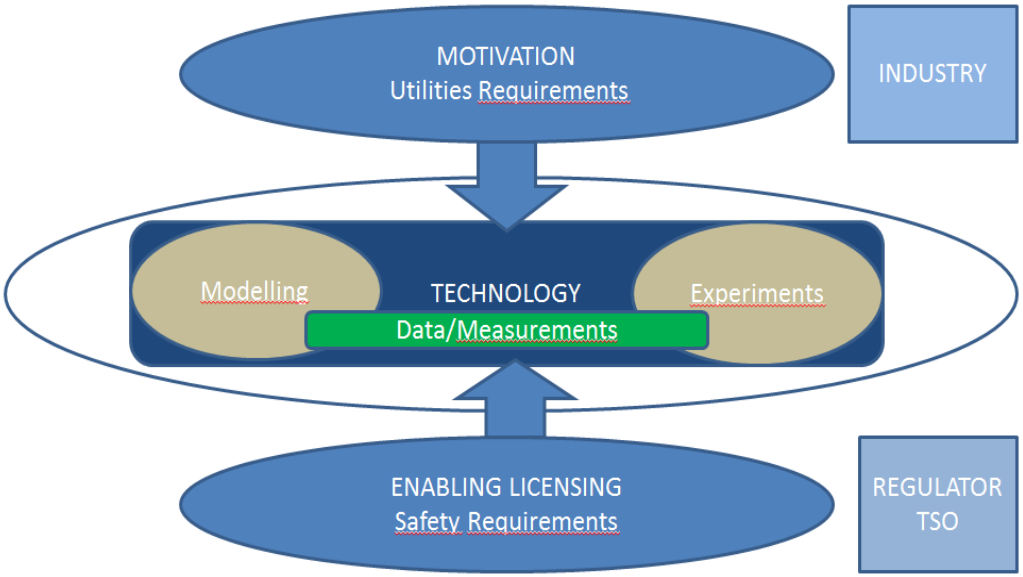
- Align TRLs and LRLs

- Define/select technology and function(s) to address (ia SiC, LOCA)

- For them design smart experimental programme (what to experiment) and optimise use of experimental facilities with support of modelling, based on improved data collection and management (how to experiment) TBC

- Each action above to be implemented by ad-hoc mechanism, existing or to be created – ia NEA Working Groups and/or Joint Undertakings

- Involving committed Stakeholders



CONCLUSION

NI2050

- is a flexible framework overarching all NEA activities

- allowing to engage the very right people

- to identify topics for innovation and produce vision roadmaps

- and to foster, within NEA, opportunities for the implementation (PoW, Working Parties, Joint Projects)