Framework of Nuclear Energy Policy

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1. Introduction
   - Nuclear energy
   - Nuclear energy policy
   - The objective of this lecture

Nuclear Energy

- Energy is not a material commodity; it is an abstract concept invented by physical scientists in the 19th century to describe quantitatively a wide range of natural phenomena. We identify thermal energy, kinetic energy, mechanical energy, nuclear energy, radiant energy etc. It is a quantity that obeys a conservation principle (The First Law of Thermodynamics).
- Although all forms other than thermal energy can be completely converted into thermal energy, the reverse process is impossible. Only a portion of the thermal energy from a thermal plant can be converted into mechanical energy and the rest reappears as lower temperature heat or less useful thermal energy (The Second Law of Thermodynamics).

Nuclear Energy (cont'd)

- Nuclear energy is released as radiant energy (radiation) by changes in the structure of nuclei (fission, radioactive decay).
- In nuclear reactors, nuclear energy released by fission of fissile material that captures neutron is converted into thermal energy via heating nuclear fuel material. The thermal energy is converted into kinetic energy of gas or steam, which generates mechanical energy in a turbine that in turn will yield electrical energy that is transported via conducting cable to load centers.
- Radiation is generated via radioactive decay of elements or particle accelerators also. Radiation is used in biology, medicine, agriculture, chemistry, environmental protection, material science and industry.

Public Policy

- A public policy is composed of effective actions of Government for change with regard to identified need for change in a manner consistent with law and institutional customs. Its major elements are goals, causality, tools, targets and implementation.
- Public policies are, in a simplest term, divided into three categories: distributive, redistributive, and regulatory policy:
  - Distributive policies involved the granting of some sort of benefits to a particular interest group:
  - Regulatory policies are to govern the conduct of business:
  - Redistributive policies are to manipulate the allocation of wealth, property, civil rights or some other valued items among social classes or groups.
- There are groups seeking policy change that seek to advance issues closer to the governmental decision agenda and groups opposing change that seek to block issues from advancing on the agenda. Accordingly various interests are organized and react to different kinds of policies in public policy processes. In the end, a group of policies related to a change often are promoted by various departments of the Government.

Atomic Energy Basic Act (Japan)

- Goals of promoting research, development and utilisation of nuclear energy
  - Securing energy supply
  - Promoting science and industries, and thereby
  - Contributing to the improvement of both welfare of human society and the standard of living of the people
- Conditions of the promotion
  - Limiting them to peaceful purposes
  - Assuring their safety
  - Conducting them democratically
  - Opening their results to the public, and
  - Promoting international cooperation
- (Nuclear Energy Policy) AEC should plan, deliberate and decide a principal guide to action taken by the various department of the Government for the promotion of research, development and utilization of nuclear energy in accordance with these goals and conditions, including regulatory measures, laws, and funding priorities.
- The regulation of nuclear safety regulation, nuclear security and nuclear safeguards should be promoted by the Nuclear Regulatory Agency (NRA).

Roles of the Government

- Atomic Energy Basic Law suggests that the Government should take active steps for facilitating energy companies to build and operate nuclear power plants so as to promote public interest, adopting within its national legal system of such legislation, regulations, and other standards and measures as may be necessary to fulfill its responsibilities and international obligations.
- The role of the Government should be therefore;
  - ✧ To promote R, D and U of nuclear energy science and technology with a view to ensuring a level playing field to various energy technologies that are promising to promote public interest: it should be energy companies that fund, develop and build new nuclear power stations, including meeting the full costs of their decommissioning and their full share of waste management costs.
  - ✧ To establish and maintain an administrative framework that provides for the regulation of facilities and activities that give rise to radiation risks and for the clear assignment of responsibilities and international obligations.

Nuclear Energy Policy is Promoted by Various Government's Departments in UK.

- Reducing the UK's greenhouse gas emissions by 80% by 2050 (Defra, DFT, DECC and CCC)
- Using evidence and analysis to inform energy and climate change policies (DECC, CCC and ONS)
- Countering weapons proliferation (BIS, DFID, DECC, FCO and MOD)
- Reducing the impact of climate change in developing countries (DFID, DECC and FCO)
- Increasing the use of low-carbon technologies (DFT and DECC)
- Taking international action to mitigate climate change (Defra, DFID, DECC and FCO)
- Maintaining UK energy security (DCLG, DECC and Ofgem)
- Controlling defence, security and dual-use strategic exports (BIS, DFID, DECC, FCO and MOD)
- Managing the use and disposal of radioactive and nuclear substances and waste (Defra, DECC, CoRWM, NDA and EA)
- Providing regulation and licensing of energy industries and infrastructure (DECC, PINS, The Coal Authority and HSE)

Department for Business, Innovation & Skills (BIS) , Committee on Climate Change (CCC), Department for Communities and Local Government (DCLG), Department of Energy and Climate Change (DECC), Department for Environment, Food & Rural Affairs (Defra), Department for International Development (DFID), Department for Transport (DFT), Department for Work & Pensions (DWP), Environmental Agency (EA), Foreign & Commonwealth Office (FCO), Health and Safewty Executive (HSE), Ministry of Defence (MOD), Office for National Statistics (ONS), Planning Inspectorate (PINS)

The Objective of this Lecture

- This lecture is to present agenda of and a process to formulate a nuclear energy policy, taking the Framework for Nuclear Energy Policy of JAEC as an example.
- The objective of the lecture is to introduce
  - how problems are identified and placed on the public agenda for the promotion of nuclear energy utilization, and
  - how nuclear energy policies are formulated and adopted in a state.

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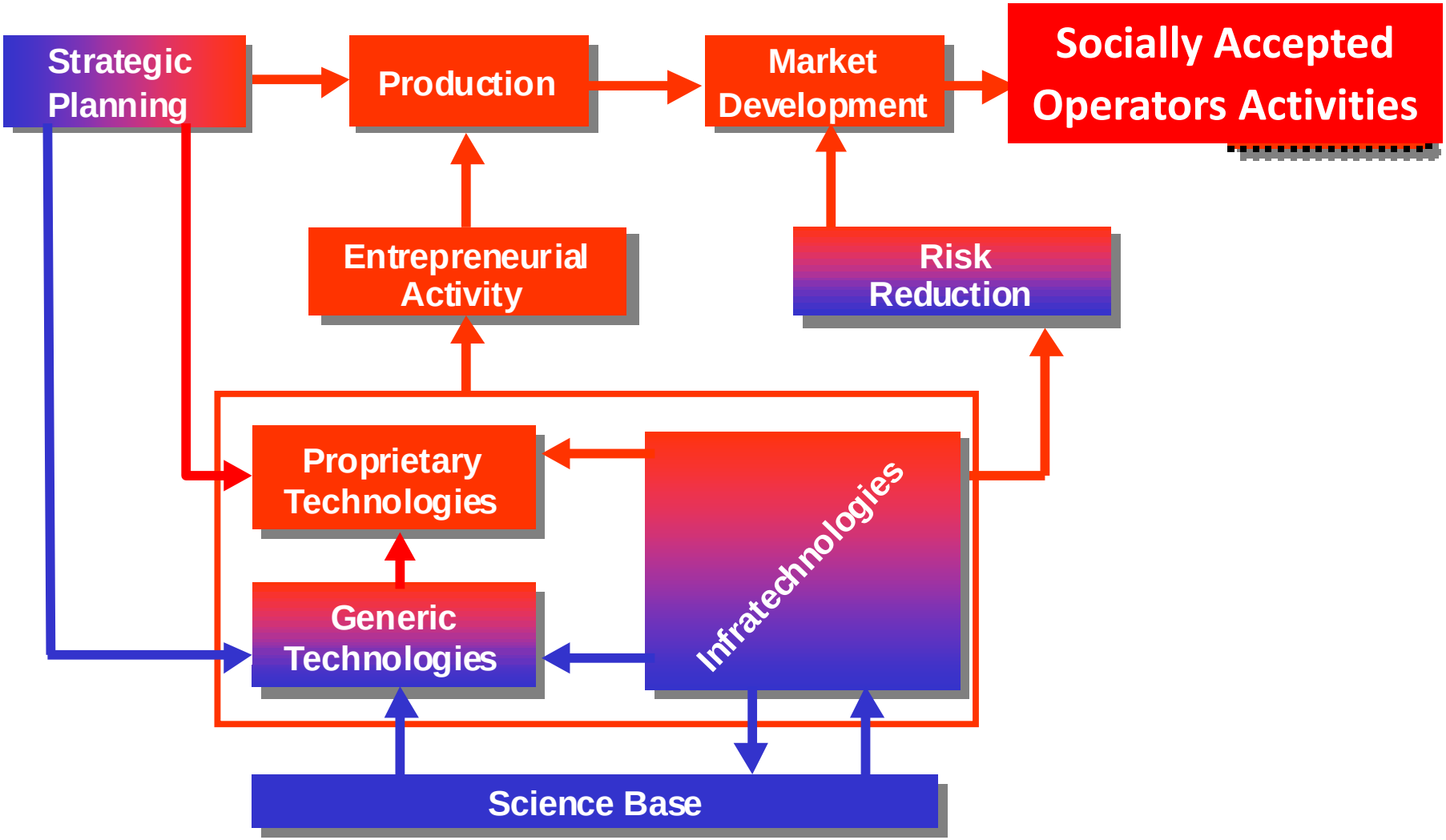
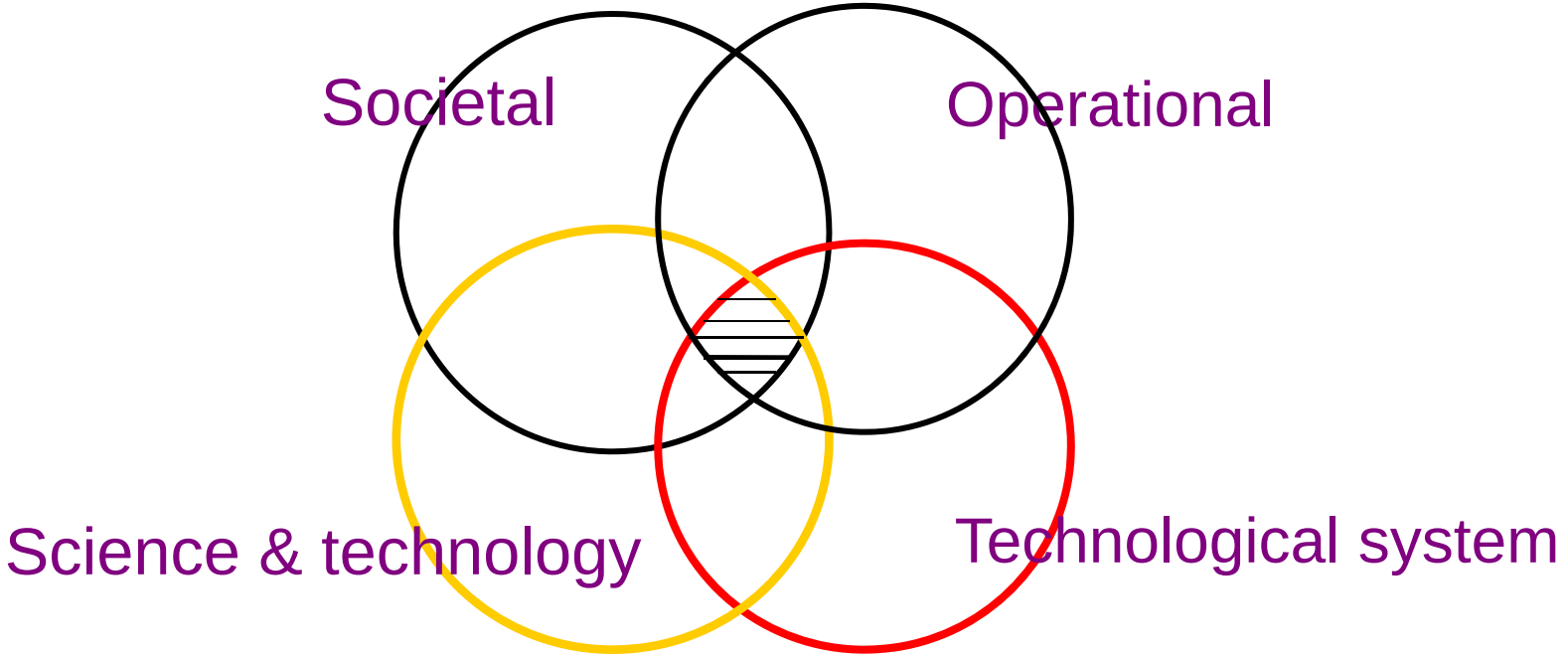
Economic Model of a Technology-Based Industry



Source: G. Tassey, *The Economics of R&D Policy* Quorum Books, 1997, p. 70

Utilization of Nuclear Energy is Possible Only When Scientific, Technological, Operational and Societal Conditions are Overlapping in Consistent Manner



Major Agenda in Science & Technology Subspace

- Need for relevant scientific and technological bases
  - Science basis
  - Generic technologies
  - Nuclear reactor technologies
  - Nuclear fuel cycle technologies
  - Technology infrastructure
- Measures to make these bases available is to promote
  - Purely basic research for better understanding, i.e. science basis
  - User-inspired scientific research for usable technologies
  - Applied R&D for improved technologies
  - Design, construction and operation of prototype and demonstration facilities
  - Technological infrastructure development

Major Agenda in Technological System Subspace

- Need for capability to design, manufacture and construction of usable nuclear facilities
- Measures to assure their supply
  - Develop and maintain such capability
  - Develop technology standards for usable technologies
  - Nurture industrial bases for production and construction of nuclear facilities
  - Cultivate and maintain the willingness of industries to establish/maintain/expand the supply chain of these products
  - Cultivate willingness of foreign industries to export these products

Major Agenda in Operation Subspace

- Need for operators
  - Operators who can operate, maintain and decommission nuclear facilities and manage radioactive wastes in safe, effective and efficient, and socially acceptable manner.
- Measures for assuring the existence of such operators
  - Cultivate and maintain the willingness of electric utilities to operate, maintain and decommission nuclear facilities and manage radioactive wastes in safe, effective and efficient, and socially acceptable manner.

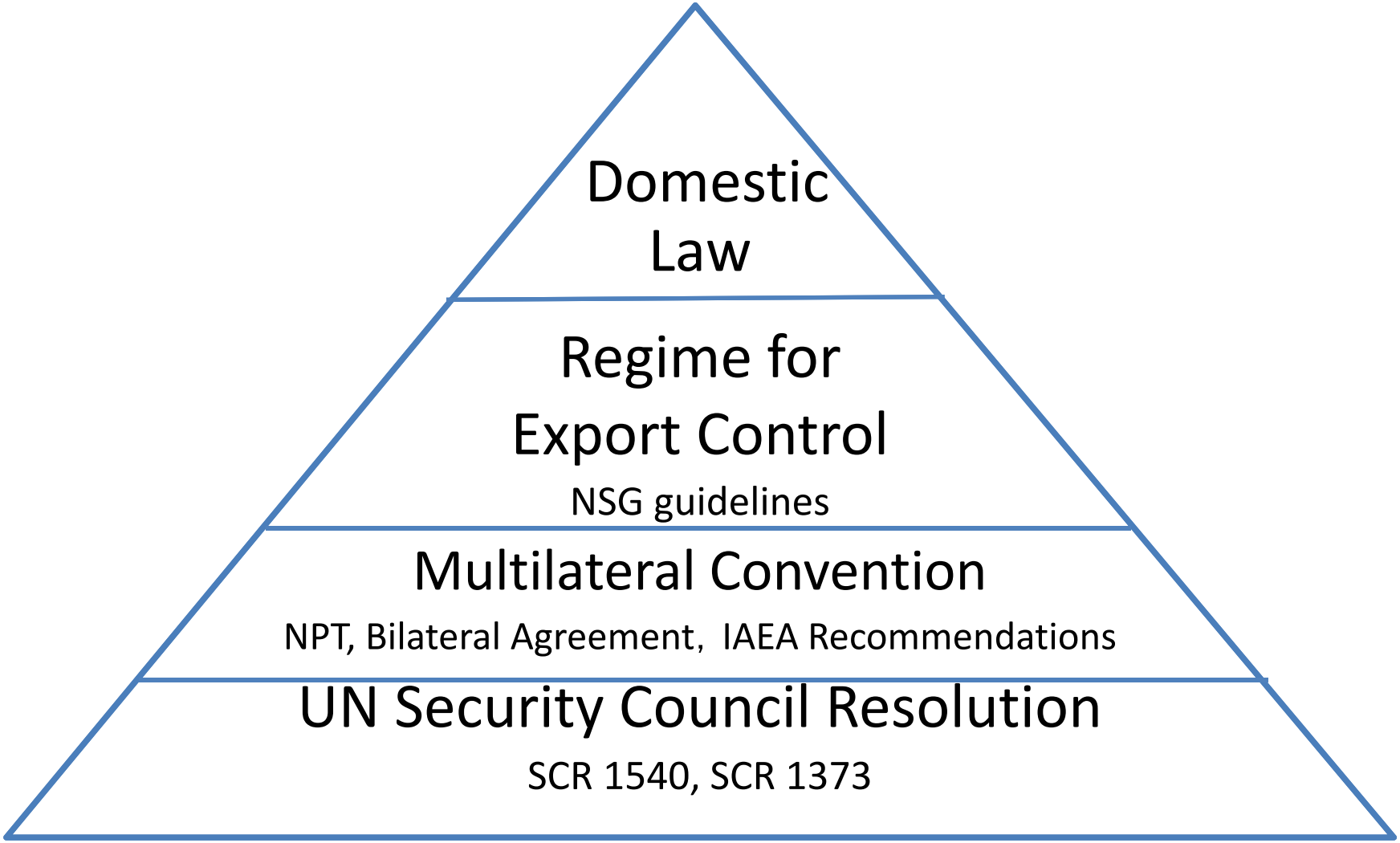
Major Agenda for Diffusing Radiation Application Technology

- Need for usable innovative radiation application technology
- Measures for assuring the availability of such technology
  - Promote the R&D of radiation sources
  - Prepare user-facilities (radiation sources) for R&D
  - Encourage industry to manufacture accelerators
  - Encourage industry to supply isotopes for diverse utilization
  - Promote the management of radioactive waste generated from such application

Major Agenda in Societal Subspace

- Need for societal arrangement and the public acceptance for nuclear energy technology or option space for the technology
- Measures for assuring social arrangement and acceptance
  - Pursue public acceptance of nuclear energy R, D and U for energy generation and other benefits.
  - Cultivate and improve nuclear literacy of the public
  - Develop human resources for nuclear energy R, D and U
  - Establish and maintain independent regulatory authority for nuclear safety and security
  - Satisfy International obligations, including the assurance of nuclear safeguards, maintaining effective State Systems of Accounting for and Control of Nuclear Material (SSACs) in consultation with IAEA.
  - Request operators to establish friendly relation with stakeholder
  - Promote effective International relations (bilateral, multilateral, universal)

Structure of Laws (Soft Laws and Hard Laws) for Nuclear Security and Nonproliferation that Should be Respected in Design and Promotion of Nuclear Energy Policy



3. Framework of Nuclear Energy Policy

- Goals
  - Role of nuclear energy
  - Nuclear fuel cycle policy
- Near-term policy Issues
  - Credibility of nuclear energy policy
  - Credibility of nuclear regulator
  - Reliability of nuclear operators
- Mid-term policy issues
  - Nuclear literacy of the people
  - Sufficiency of human resources
  - Determination of site for geologic repository for HLW
  - Industrial policy
- Long-term policy issues
  - Technology research and development
- International Cooperation
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Role of Nuclear Power

- Japan should secure and promote the right of access to safe, sufficient and economical energy services to its people.
- Safety considerations should be central elements for energy policy; risk and impact assessments of energy sources throughout its whole life cycle inform us that though nuclear energy is not a risk-free energy source, the risk can be made acceptably low without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risks, by means of an effective management system.
- Security of energy supply is one of the main policy targets: since Japan is highly dependent on fossil fuel imports, energy supply is vulnerable and Japan wants decrease its vulnerability to imported energy sources in a sustainable and environmentally sound manner.

Role of Nuclear Power (cont'd)

- The current sources of energy rely mainly on fossil fuel, which are limited. The use of fossil fuels causes significant climate change that is the issue pertaining to international justice and responsibility. Japan is committed to the reduction of the emission of greenhouse gases. The power generation based on nuclear energy is not only dependent on less limited raw materials but also an emitter of far less GHG than fossil fuel.
- The Government believes that as nuclear is cost competitive with other generation technologies, nuclear energy has an important role to play in delivering our long term objective of a secure, low-carbon, affordable energy future. Nuclear energy should be therefore a part of the energy mix in Japan.
- After 3.11, Japan has been in the process of reconstructing her nuclear energy policy.

Approaches for Spent Nuclear Fuel Management: Direct Disposal or Recycling

- Direct Disposal: Dispose spent nuclear fuel as high-level waste (HLW) in geologic repository
- Recycling: Reprocess spent fuel by Purex process that separates uranium and plutonium, and direct remaining transuranics to vitrified waste, along with all the fission products, that is disposed in geologic repository as HLW.
  - Use the plutonium in mixed oxide (MOX) fuel for LWRs and store the most of the recovered uranium for eventual reuse.
  - Store most of spent MOX fuel as well as other spent fuel for the time being, considering available reprocessing capacity and plan for utilization of plutonium recovered.

Advantages and Disadvantages of the Recycling Approach

- Advantages:
  - The approach helps significantly reduce the volume of spent nuclear fuel, as well as the high level wastes to be disposed of.
  - It can improve the utilization of natural uranium around 15%.
  - It is a good precursor for the closed fuel cycle based on fast reactors to be established in the latter half of this century.
- Disadvantages:
  - It results in an economic penalty over the no-recycle option: the increases in cost of electricity is 10% or so.
  - The existence of the facility to separate plutonium is considered by some to increase proliferation risk.
  - The use of a number of processes for the execution of recycling will increase radioactivity release.

Issues in Fuel Cycle Policy Debate in Japan

- Various delays and cost over-run before starting the recycling operation suggests that it is difficult to realize closed fuel cycles *in consistent with the requirement of maintaining their business risks to an acceptable level and uneconomica*l, even without considering the externalities related with nuclear nonproliferation and security, in comparison with the policy to dispose the spent fuel as waste.
- *It provides Japan with significant merit from the viewpoint of energy security* to realize closed fuel cycles .
- In addition, various activities toward the realization of closed fuel cycles and diverse societal assets accumulated in this process such as technologies, trust relationships between operators and communities, various international agreements, etc. are resources to be maintained for future if we continue to enjoy the benefit nuclear energy can bring about.

Conclusion of Policy Debate

- Considering the current status, it is appropriate for Japan to pursue the recycling of fuel materials through reprocessing from the viewpoint of utilizing nuclear power as a long-term and major method of power generation.
- The entities should be flexible in the realization of activities planned through rigorous risk assessment and management. The Government should start from 2010 the deliberation of the future fuel cycle strategy to be followed after the retirement of Rokkasho Reprocessing Plant (RRP), taking into consideration of the progress in the R&D for fast reactor and its fuel cycle systems.
- In order to prepare ourselves to such reviews, it is appropriate to maintain basic research on the science and technology necessary to the review of alternative strategies such as direct disposal also.

Goals for Three Time-Frames

- The energy problem, like many others, consists of issues having a multiplicity of time horizons, which stretch from very short to very long.
- Therefore it is usually decided in the policy deliberation to pursue a set of actions that intend to get the result in several different time frames, e.g., short-term, mid-term, and long-term, in parallel.
- In the case of Strategic Energy Technology Plan (SETP) of EU, time frames of short-term (~2015), medium-term (~2020), and long-term (~2050) are used.

Near-term, Mid-term and Long-term Goals for Nuclear Energy Utilization

- **Near-term:** use existing assets as efficiently as possible
  - Restart the idling plants after strengthening severe accident management capability, satisfying the requirement set by the NRA.
  - Restart the use of plutonium and uranium recovered through the reprocessing of spent fuel in LWRs.
- **Mid-term:** introduce change/add assets
  - Construct intermediate spent fuel storage facilities.
  - Determine the site for geological repository for HLW.
  - Replace the retiring plants with advanced light water reactor designs.
- **Long-term:** develop new products and processes
  - Utilize fast reactor and its fuel cycle system technology for the reduction of volume of high-level radioactive waste.

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Maintain Credibility of Nuclear Energy Policy

- Energy that is accessible to all, that is secure, safe and competitive is the guiding principle for energy policy formulation. The solutions and actions advocated by the governments, authorities and academia need to pursue the benefit of the entire society.
- Chernobyl and then Fukushima both provided a vital reality check on the safety of nuclear facilities. In addition, the concerns about radioactive waste management (RWM), safe and respective for future generation, remain one of the main preoccupations in the minds of citizens.
- Civil society is looking to the policy makers to make these issues both more understandable and more transparent. It is thus very important that the general public represented by its civil societies is kept well informed and given the opportunity to participate in the decision making.
- The Government should promote risk communication for those living near existing or proposed nuclear facilities, presenting risk information in accessible formats and language, in addition to making technical documents available in the interests of transparency.

Maintain Credibility of Nuclear Energy Policy

- In 2012, the Government consulted with the public about the future of nuclear power in energy portfolio or mid- and long-term goal of nuclear energy policy. However, what the Government should have done is to decide what to do and how to do with the existing plants and planned activities.
- Now the Government is expected to deliberate;
  - How can we make nuclear power supply system trustworthy to the public in a rage, as continuation of the use of nuclear power for the time-being has significant merits that can contribute to the attainment of energy policy goals even under possible new condition for competition.
  - How can we continue to promote bilateral, multilateral and international cooperation and joint activities for nuclear safety, security, safeguards, R&D of nuclear technology and so on around the globe, as a responsible country.
  - How can we continue to assure the safety, security and proliferation resistance of our nuclear energy supply system, building human resources enthusiastic about these tasks.
- At the same time, Government should promote risk communication with the public, presenting risk information in accessible formats and language.

Credible Safety, Security and Safeguards Regulation

- The government should maintain effective and independent administrative frameworks for regulate safety, security and safeguards.
- The government should maintain all safeguards measures including effective State Systems of Accounting for and Control of Nuclear Material (SSACs) in consultation with IAEA.
- The regulatory body must have adequate legal authority, technical and managerial competence, and human and financial resources to fulfill its responsibilities of making sure that
  - Principle 5: Protection is optimized to provide the highest level of safety that can reasonably be achieved (optimization of protection).
  - Principle 8: All practical efforts are made to prevent and mitigate nuclear or radiation accidents (prevention of accidents).
  - Principle 9: Arrangements are made for emergency preparedness and response for nuclear or radiation incidents (Emergency preparedness and response).

Regulator Should Assure the Public Trust

- Regulator should pursue openness, effectiveness and operational excellence:
  - Transact its business as openly and candidly as possible, explicitly recognizing that the public must be informed about, and have a reasonable opportunity to participate meaningfully in the regulatory processes.
  - Take actions that are high quality, efficient, timely, and realistic for enabling the safe and beneficial use of radioactive materials.
  - Use state-of-the-art technologies and risk insights to improve the effectiveness and realism of its actions, with a goal of continuous improvement.
  - Clarify and update technical standards for regulation based on the advanced knowledge obtained through research and operating experiences in the world.
  - Hire and retain knowledgeable and skilled staff, building its human capital in diverse areas.

Nuclear Operator Should Assure Public Trust (1)

- Although regulatory bodies have an important responsibility in establishing standards and the regulatory framework for protecting people and the environment against radiation risks, **the ultimate responsibility for safety rests with the licensee.**
- Therefore the leadership of operating organizations should aim at maintaining a self-disciplined approach to the enhancement of safety beyond legislative and regulatory requirements, making **safety culture** inherent in the thoughts and actions of all the individuals at every level in an organization. The same approach should be followed for security and safeguards.
  - ✓ **Safety culture is an assembly of characteristics and attitudes in organizations and individuals, which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.** (INSAG)
- In UK, the Courts have decided that, in judging whether duty-holders have done enough to reduce risks, practicable measures to reduce risk can be ruled out as not 'reasonable' only if the sacrifice or otherwise termed costs involved in taking them would be **grossly disproportionate** to the risk.

Nuclear Operator Should Assure Public Trust (2)

- Operators should work with local government and the public for building trust around nuclear facilities. Operators should promote communication with local communities about their safety assurance measures, placing priority on the understanding of what the people really wants to know.

  Accept facility visit by the public as “seeing is believing” and “seeing” helps to foster familiarity, though the tension between need for easy entry versus need for stringent physical protection should be solved beforehand.
- Community benefits are an important way of building trust. Offering shares in projects to develop infrastructure related with the nuclear facilities could form part of community benefits for the facilities. Negotiations can enable the public to feel a greater sense of control, choice over and ownership of the projects. Partnership thus generated will be conducive to building trust and acceptance.

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Nuclear Literacy of the People

- More and more scientific and technological issues dominate nation discourse. Therefore all citizens need to be scientifically literate to make informed personal choices. Without an informed electorate some of the most fundamental objectives of our nation may not be served.
- The Government should support the learning about energy and nuclear science and engineering in formal education, and activate diverse networks for the public to learn about energy issues and nuclear energy.
- Enrich the exhibits and programs on nuclear science and engineering including nuclear energy activities in the museums and science centers across the country in order to support formal education, professional development for teachers who are in charge of the education as well as people's life-long learning in these topics.
- These should contribute to building a clear image of the roles for engineers and scientists in the mind of the public and prospective students who can replenish and improve the talent base of an aging engineering workforce.

Human Resource Development

- Key elements of policy deliberation
  - Clarification of the need for engineers and researchers in scientific sectors
  - Clarification of the need for engineers and researchers in industrial sectors
  - Definition of the knowledge and skills requirements
  - The willingness of learning providers to respond to these needs
  - The willingness of employers to lead skills development, driving the skill developers and learning providers.
  - The public funding for these activities.

Human Resource Development (2)

- Enhancing opportunities for nuclear education in various educational institutes, as many who studied mechanical engineering, electric and electronic engineering, chemical engineering and so on are active in nuclear industry.
- Enhancing education concerning radio therapeutics, radiation medicine and radiation science to respond to the increased demand for specialists in these disciplines. It is important for the parties concerned to expand this activity as early as possible, collaborating with each other, and extend their efforts to enhance radiation education in medical departments.
- The Integrated Center for Nuclear Nonproliferation and Nuclear Security of the Japan Atomic Energy Agency (JAEA) is responsible for developing human resources for nuclear security and safeguards. Suitable promotion of this work is expected, taking into account the demand for human resources and supply gaps in Asian countries.
- New requirements as a lessons learned from Fukushima:
  - Nuclear education in educational institutes should take into consideration of lessons learned from the accident at Fukushima Dai-ichi Nuclear Power Plant.
  - Offer an intellectual environment focusing on the accountability to society, and enhancing the experience of internship in nuclear facilities for which such accountability is required.

Nuclear Education and Training : Key Elements of a Sustainable European Strategy: Recommendation of Working Group on Education, Training and Knowledge Management: Sustainable Nuclear Energy Technology Platform

Challenges: there is a real risk of the loss of nuclear knowledge for the European Union if no measures are taken, and preservation of skills in the nuclear field requires general effort involving public and private players and in particular the nuclear industry, considering current issues such as

- The lack of engineers and researchers in scientific sectors;
- The need to take appropriate measures to ensure that nuclear energy remains a safe option in those Member States that have chosen or will choose it;
- The long-term availability of qualified human resources in view of the continued exploitation of nuclear energy in several Member States, whereby 152 reactors currently supply the EU with 31% of its electricity;
- The need for and the importance of training and teaching of skills through involvement in R&D in all subject areas: design and construction, radiation protection, radioactive waste and materials management, operation of installations and decommissioning;
- The age profile within the workforce, in particular the many retirements likely in the short term.

Nuclear Education and Training : Key Elements of a Sustainable European Strategy: Recommendation of Working Group on Education, Training and Knowledge Management: Sustainable Nuclear Energy Technology Platform (2)

Highlighted needs:

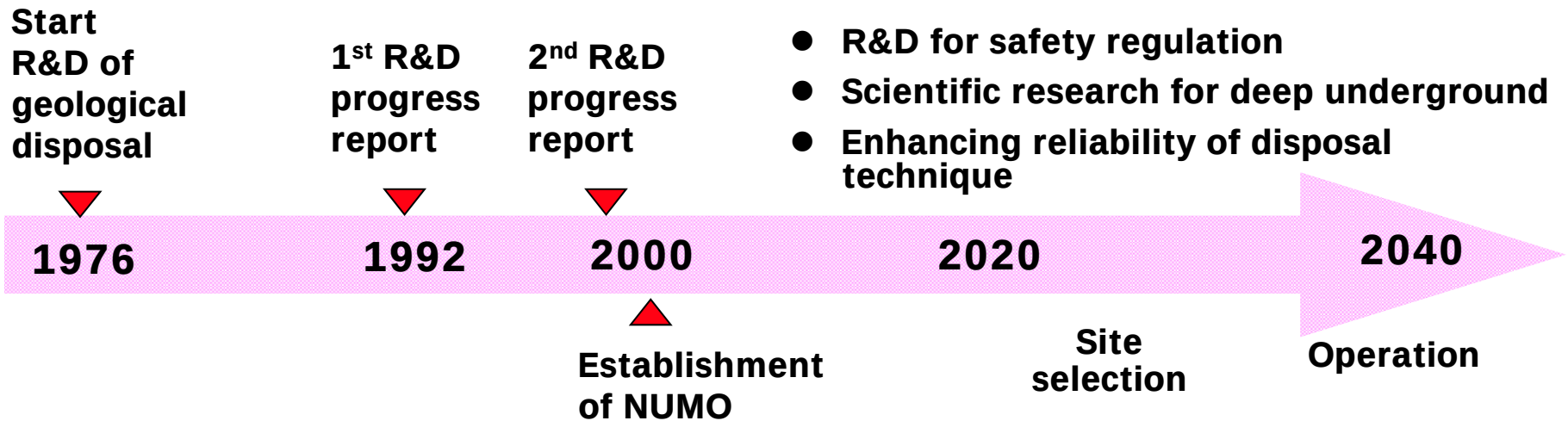
- The creation of appropriate conditions for mutual recognition of nuclear professional qualifications throughout the EU;
- Reinforcing the teaching of basic scientific skills in preparation for energy-related occupations, and giving a new impetus to the teaching of mathematics, physics and chemistry at every level;
- Developing generally the provision of programmes in different languages specifically geared to energy-related and especially nuclear related occupations;
- Assessing ways of attracting more European and non-European students to these programmes by improving the competitiveness of scientific and technical careers in public and private companies within the EU;
- Equipping European universities and institutions involved in nuclear-related teaching programmes with the capacity to accept such students;
- Where necessary extending the network of institutions and universities offering this type of teaching, and ensuring mutual recognition of qualifications obtained in other Member States;
- Improving the visibility of European nuclear training as currently organised in associations and networks, which constitutes a recognised global reference;
- Making available common European technical documentation and teaching material, in particular through the use of new information technologies.

Nuclear Education and Training : Key Elements of a Sustainable European Strategy: Recommendation of Working Group on Education, Training and Knowledge Management: Sustainable Nuclear Energy Technology Platform (3)

Recommendations

- Key stakeholders in nuclear energy and nuclear safety should develop a 'common language' for employment as well as education and training for nuclear energy, including a common taxonomy of skills and competencies linked to jobs.
- Key stakeholders in nuclear energy and academic institutions should **engage in a joint action to optimise the curricula** of academic programmes related to nuclear energy with special regard to the needs by 2020 and to the potential synergies between academic and non-academic programmes for graduates.
- Private-public partnerships for nuclear education and training **need further support and funding** in order to be able to cater for the expansion in E&T programmes, the training of trainers and providing the necessary guidance.
- The framework for **mutual recognition of qualifications** should be further developed with the objective of gradually including non-academic qualifications and related vocational training. This should include the identification of 'Competent Institutions' in the EU that can provide qualifications or portfolios of learning outcomes, and pilot exercises to apply the 'learning outcomes' approach within ECVET (European Credit System for Vocational Education and Training) partnerships.
- Recent European initiatives such as EHRO-N (European Human Resources Observatory for the Nuclear Energy Sector) , ENEN (The European Nuclear Education Network, which in 2005 **established a European Master of Science in Nuclear Engineering(EMSNE)**) and JRC databases, which depend on input from and cooperation with national organisations, should receive appropriate support.
- The existing European initiatives for **facilitating transnational access to facilities** for the purpose of education and training should be optimised and coordinated in view of building a European platform for E&T-related facilities and IT infrastructure.
- The existing European initiatives for **cooperation with non-European countries** in nuclear education and training should be strengthened and integrated as part of the general strategy of enhancing international cooperation in nuclear research and nuclear safety.
- Key organisations within the EU should cooperate in the further development and maintenance of European databases and IT platforms intended to support nuclear education and training and in the provision of information on related programmes and opportunities.

Develop Geologic Repository for High-Level Radioactive Waste



*Activities of **NUMO**: Nuclear Waste Management Organization*

~ 2007 Selection of preliminary investigation areas

~ 2012 Selection of areas for detailed investigation

~ 2027 Selection of site for repository

Siting of a HLW Disposal Facility

- In 2002, the NUMO, an organization authorized to promote the disposal activity in 2000, started to invite mayors of municipalities to apply for site suitability investigation. Although there have been several preliminary moves and one failed application, so far no mayor has successfully applied.
- The Government as well as the NUMO have started to strengthen public information activities on the safety and the importance of the disposal facility at both national and municipal levels, taking into consideration lessons learned from the difficulties mayors have confronted with.
- Proactive approaches have been introduced, in parallel with pursuing the present explain-and-wait approach.
- A Result of Opinion Poll (Nov. 2009)

  Do you think it our generation's responsibility to decide the site for geologic repository for HLW?

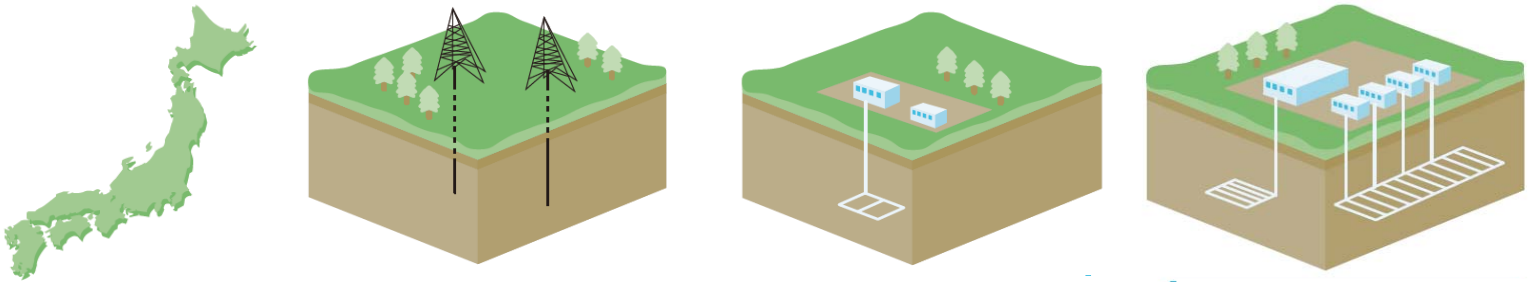
Yes, I think so.	51.9%
On balance I think so.	30.3%

  How do you think if your or your neighboring municipality plans to invite the repository?

I agree.	3.3%
On balance I agree.	12.9%
On balance I disagree.	34.3%
I disagree.	45.3%

Outline of Disposal Site Selection Process

※ If the mayor of the municipality or governor are opposed, NUMO will not go to the next phase.
※ Cabinet decision is necessary for the selection of sites.



Application for volunteer

Proposal by the central government

→ **Selection of preliminary investigation areas based on the literature survey※**

→ **Selection of detailed investigation areas based on the preliminary investigation by boreholes around 2013※**

→ **Selection of site for construction detailed investigation based on the investigation by underground facilities around 2028※**

→ **Construction of disposal facility ↓ Commencement of disposal (Mid-2030s)**

AEC is suggesting the Government to;

- Revise the report on the scientific basis on the safety of geologic disposal, taking into consideration of the newest knowledge in seismology.
- Continue actions to promote mutual communication with the public patiently, exploring innovative ways for increasing the probability of application.
- Prepare facilities that demonstrate the concept of the repository and the safety of the disposal: a picture is worth a thousand words.

Nuclear Industrial Policy

- Taking into consideration public interests comprehensively, the Government should establish suitable environment for inducing the private sector to make long-term investments for the construction of new plants at home and abroad.
- Government should identify and characterize good elements of innovative technology related to various improvements needed for advancement of LWR technologies, and fund for the demonstration of such innovation in a timely fashion.
- Manufacturers are expected to strengthen their business structure and achieve the scale and competitiveness to be able to compete in international markets.

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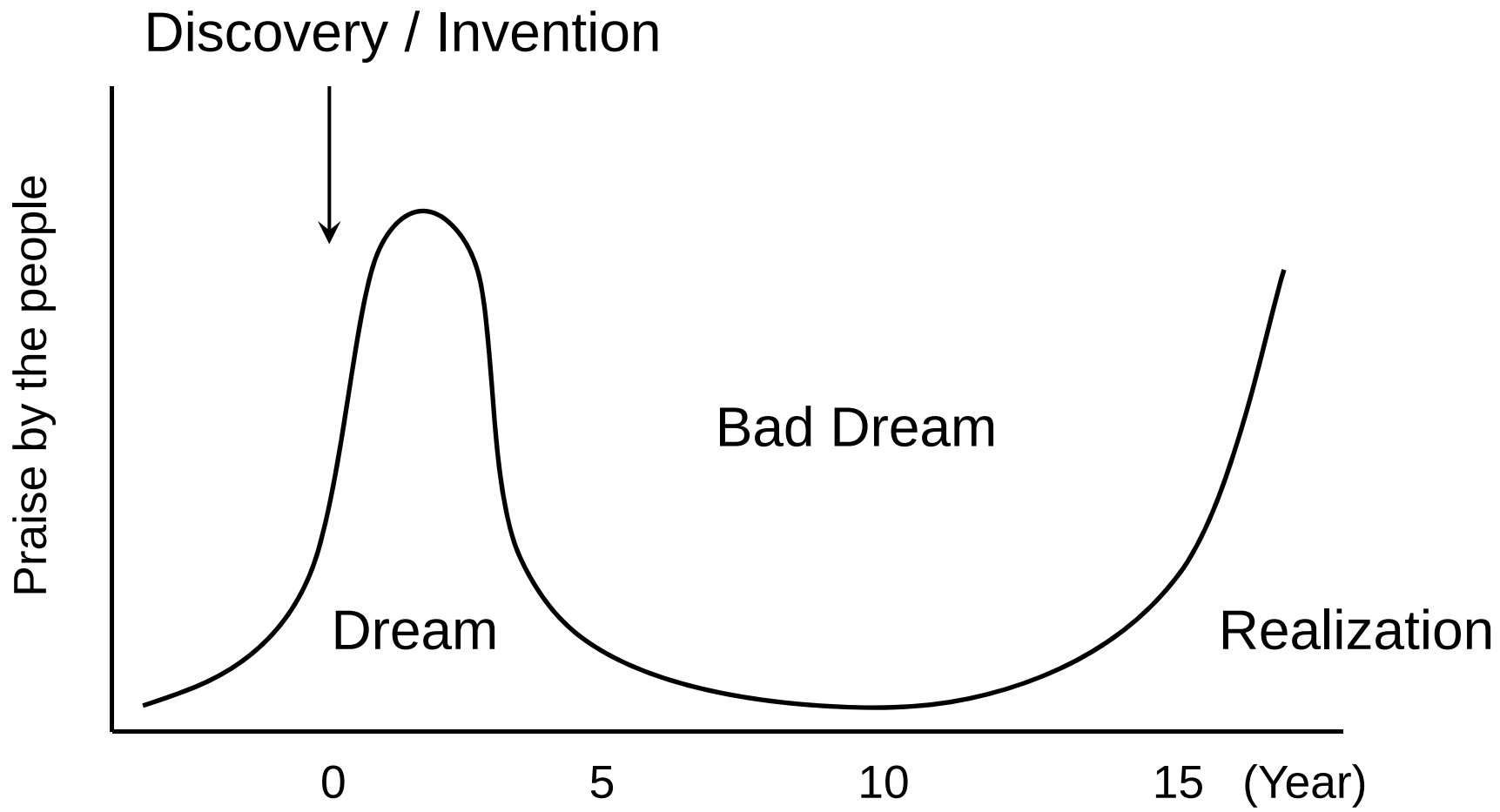
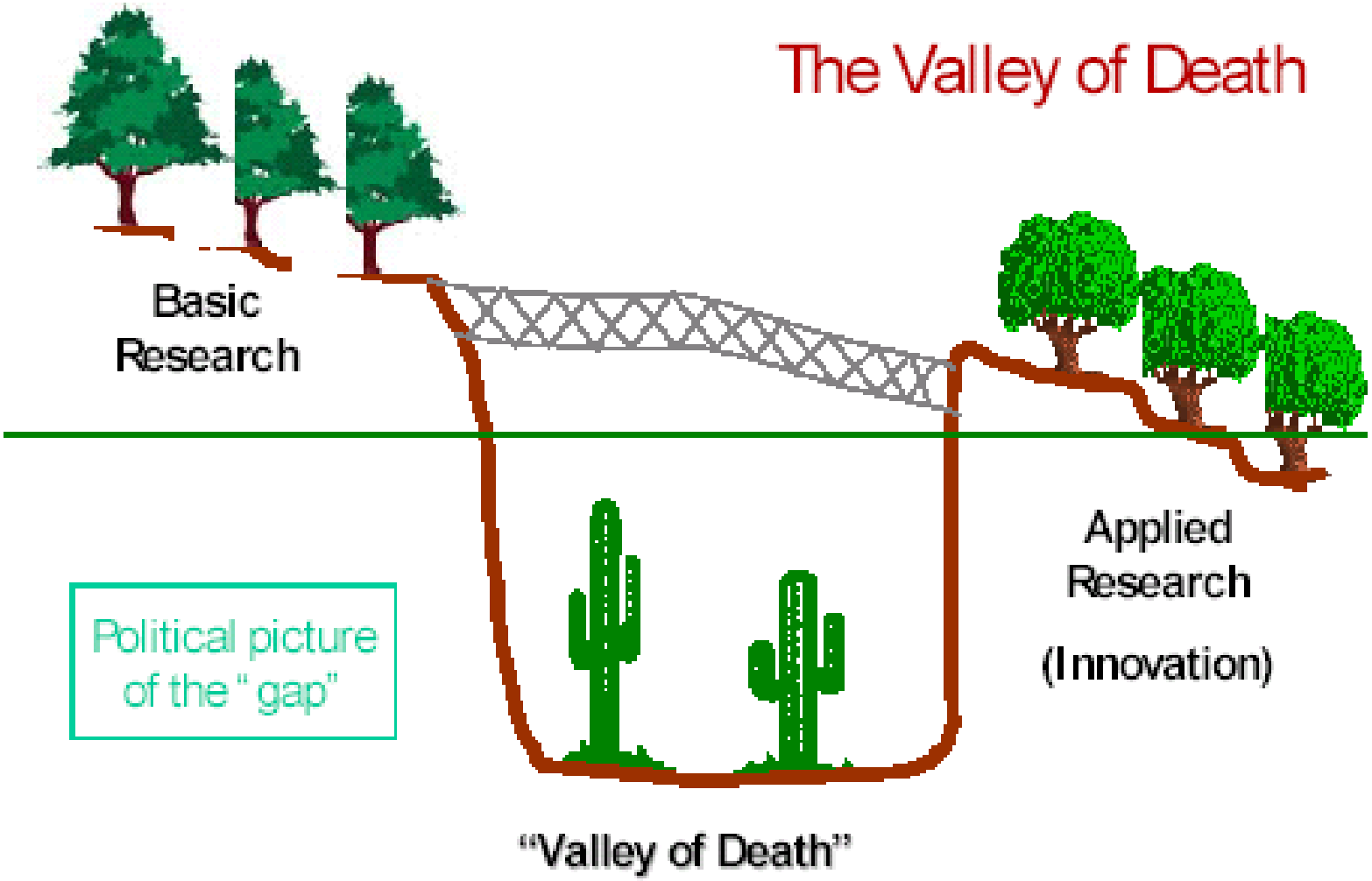
Technology Development Policy

Roles of the Government

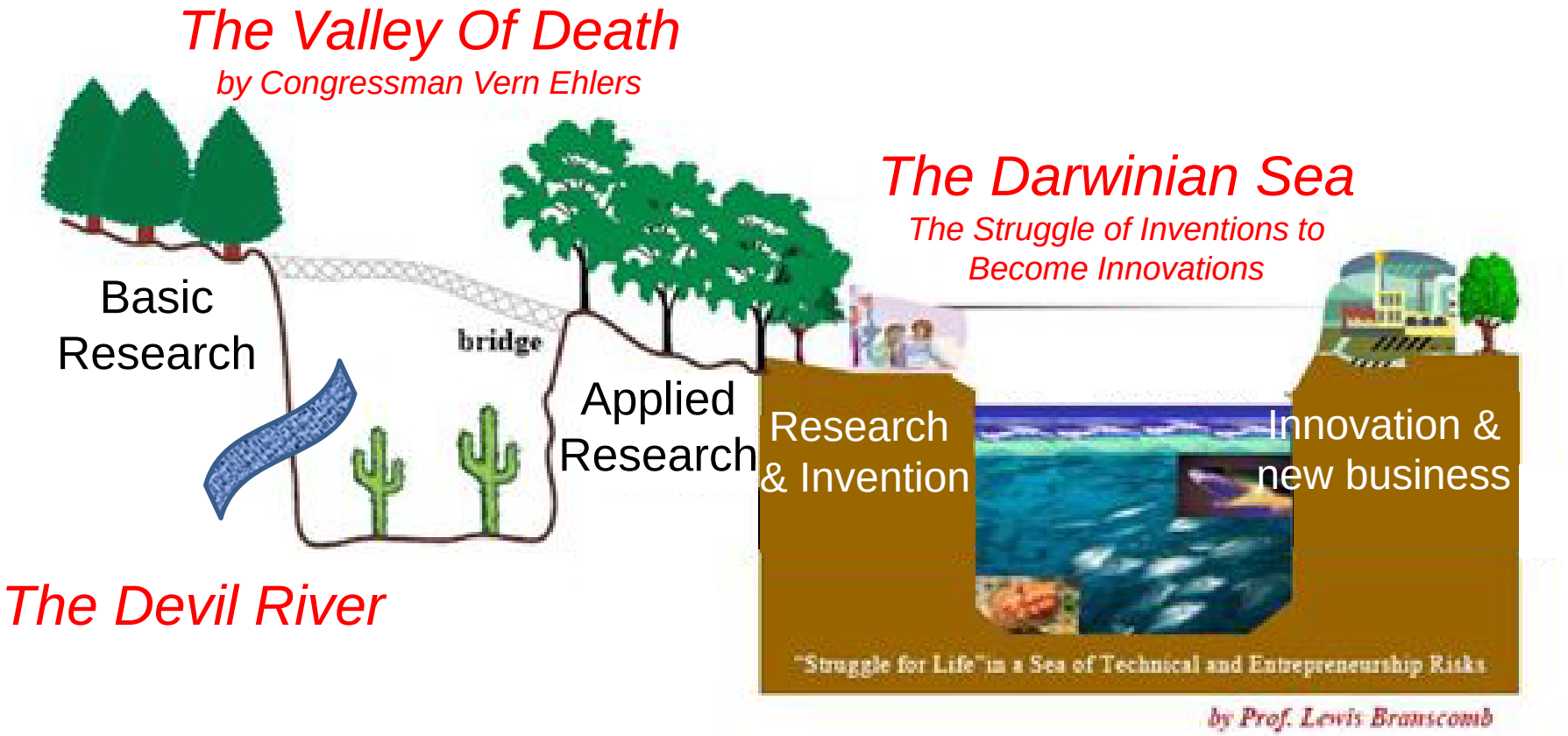
- Identify sources of innovation in technology and service that will bring about the maximum benefit to society but cannot be realized by the private industry by itself, such as
  - High-risk and high-return innovation
  - Innovation in system technology, complex technology, trans-disciplinary technology
- Induce the realization of such innovation by investing into the initial phase of its realization with a view to encouraging industry to cross the Devil River, the Valley of Death and or Darwinian sea.



Dream – Bad Dream – Realization : Process of technical realization:
Yoshikawa (1985)



The "Valley of Death" image, as drawn by US Congressman Vern Ehlers.



Innovation is successfully realized after crossing the Devil River and the Valley of Death and surviving in the Water of the Darwinian Sea

Role of Government to Assist Innovation

- Devil River: narrow but deep
  - From basic research to applied research
  - Money for testing an idea for an innovative product
- Valley of Death: bridge is narrow and fragile
  - From principle of product to a successful prototype
  - Venture capital for prototyping
- Darwinian Sea: survive in the sea full of sharks
  - Survival of the fittest product to the market
  - Removal of entry barrier, technology management for cost down and market development / market-in

Need for Research and Development

- Promote R&D to improve safety, reliability and competitiveness of LWRs
  - improve understanding and numerical representation for the relevant phenomena involved in incidents and accidents at NPPs in order **to increase the realism of plant behaviour assessment** and to enhance the accuracy of safety margin assessment.
  - Improve understanding of some **predominant phenomena in severe accident (SA)** such as in-vessel corium/debris coolability, ex-vessel corium interactions and coolability, containment behaviour including hydrogen explosion risk and source term so as to improve Severe Accident Management Guidelines (SAMGs) and design new prevention devices or systems for mitigation of SA consequences.
  - improve understanding for better reactor operation in the areas of **human and organisational factors, integration of digital technologies**, core management, water chemistry and LLW management and radiation protection
  - improve understanding, and to develop methods and tools for **increasing the safety and availability of systems, structures and components** needed for reliable and safe management of nuclear power plant lifetime in the areas of integrity assessment, material performance, ageing monitoring, monitoring and prevention, and mitigation of ageing etc.
  - Improve **nuclear fuel** for existing, advanced and innovative core designs, aspects of fuel use in reactors and the fuel management on the one hand and develop **waste minimisation strategies and efficient dismantling technologies for structures** and components, including remote dismantling techniques, on the other.

Need for Research and Development (cont'd)

- Promote research on minimizing the mass and volume of HLW to be disposed of, the long term radiotoxic inventory and the heat generation of conditioned NW as function of time, the long term radiological impact and on lengthening the effective "lifetime" of conditioned NW, with a view to optimising HLW management.
- Promote engineering development for commercialization of innovative systems such as Advanced LWRs
- Promote technology development for commercialization of innovative fast spectrum reactors with closed fuel cycles that will allow a significant reduction in high-level nuclear waste radio-toxicity and volume, as well as an increase in natural resource (uranium) utilisation by a factor of around 50.
- Explore and develop innovative nuclear technologies, including fusion (ITER), nuclear hydrogen (HTR), ADS….

3. Framework of Nuclear Energy Policy

- Goals
  - Role of nuclear energy
  - Nuclear fuel cycle policy
- Near-term policy Issues
  - Credibility of nuclear energy policy
  - Credibility of nuclear regulator
  - Reliability of nuclear operators
- Mid-term policy issues
  - Nuclear literacy of the people
  - Sufficiency of human resources
  - Determination of site for geologic repository for HLW
  - Industrial policy
- Long-term policy issues
  - Technology research and development
- International Cooperation
- Promote Policy review

Major Agenda for International Cooperation

- In relation to near-term goals
  - Contribute to the maintenance and strengthening of international non-proliferation regime
  - Contribute to the activities of international organizations to provide needed services to the global communities
- In relation to mid-term goals
  - Support countries that want to utilize nuclear science and engineering for the promotion of public welfare and economy, including the introduction of nuclear power
  - Prepare level playing fields for Japanese nuclear industries to participate in the oversea business activities.
- In relation to long-term goals
  - Promote bilateral and multilateral R&D collaboration for better utilization of resources and reduction of project risks.

Multilateral Approaches to the Nuclear Fuel Cycle

- In 2005, Dr. ElBaradei, then Director General of the IAEA proposed multilateral approaches to strengthen the international nuclear non-proliferation regimes.
- We believe that Japan should cooperate with the IAEA to realize such multilateral schemes that can reduce unnecessary incentive for states to have national enrichment and reprocessing facilities.
- In reality, however, we are continuing to desperately struggling to devise and implement an equitable, adequate and achievable framework to assure the supply of nuclear energy services to international community.

Internationally Coordinated R&D Efforts

- As energy technologies generally change only slowly and at considerable cost, the social rate of return of the investment into nuclear energy R&D to the world as a whole is higher than to the individual countries. Therefore co-ordination of research activities beyond national prestige to reduce the duplication of effort at the world level must be an absolute priority.
- World nuclear community should pursue coordination of efforts in R&D needed to realize the required technological innovations in a timely manner. Japan should contribute to this kind of R&D efforts as well as their coordination for the benefit of global community.
- There are several types of international R&D cooperation, starting from information exchange to joint investment.

Three categories of multilateral R&D cooperation in the case of the Generation IV International Forum (GIF), which is an international framework to promote the cooperation on R&D of technologies for Generation IV nuclear energy systems, which are sustainable and innovative to deal with future global energy demand.

Framework Agreement (FA).

- The government delegates of Japan, Canada, France, United Kingdom and United States, Switzerland, Republic of Korea, Euratom, and South Africa signed the Frame work Agreement (FA).
- The purpose of this FA is to foster and facilitate achievement of purpose and vision of the GIF; the development of concept for one or more Generation IV nuclear energy systems that can be licensed, constructed and operated in a manner that will provide a competitively-priced and reliable supply of energy to the countries where such systems may be deployed, while satisfactorily addressing nuclear safety, waste, proliferation and public perception concerns. Collaboration under this FA shall be conducted on the basis of equality, mutual benefit, and reciprocity.

System Arrangement (SA)

- The SA is concluded each the Generation IV nuclear energy systems. The purpose is to establish a framework for collaboration among the Signatories, specifying the contents of the multilateral cooperation on R&D, protections of intellectual property rights and allocations of the achievements on the system level.

Project Arrangement (PA)

- The purpose of the PA is to establish a contractual relationship among its Signatories to plan, implement and manage the research and development work required for the completion of the related project of the system. The Project Plan sets forth in detail the scope of work needed to complete the Project, the allocation of work among the Signatories, the estimated cost of, or resources required for, performing that scope of work, the amount of each Signatory's estimated contribution to that cost or those resources, the estimated schedule for completing the scope of work, and any required deliverables from individual Signatories as well as from joint R&D activities.

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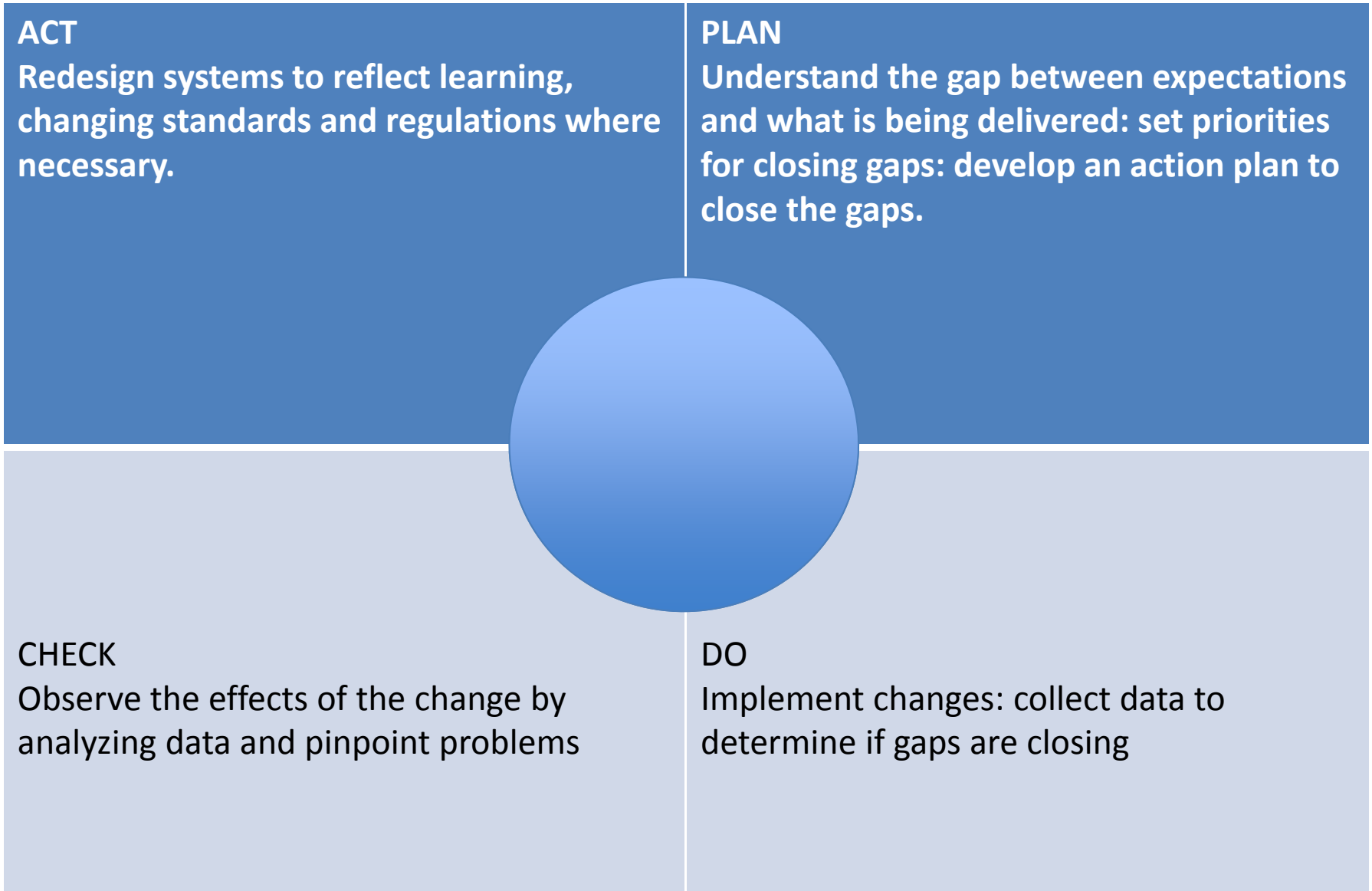
- International Cooperation
- Promote Policy review

Promote Policy Review

- It is not easy to plan necessary measures for improving public welfare toward an uncertain future, and to promote them amid a globalizing, growing and complicated environment.
- Accordingly it is definitely necessary to periodically review the policy set decided as a part of Plan-Do-Check and Action cycle, giving due consideration to activities for the quality management and risk management of the implementation of the policy, utilizing external audit effectively.
- It is also important to communicate with the public as to the effectiveness and efficiency of the policy measures taken, based on the results of these reviews.


ACT
Redesign systems to reflect learning, changing standards and regulations where necessary.
PLAN
Understand the gap between expectations and what is being delivered: set priorities for closing gaps: develop an action plan to close the gaps.
CHECK
Observe the effects of the change by analyzing data and pinpoint problems
DO
Implement changes: collect data to determine if gaps are closing