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International Atomic Energy Agency

The Role of Innovation

19th INPRO Dialogue Forum on Enhancing Public Acceptance of Nuclear Energy through Institutional Innovations

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International Project on Innovative Nuclear Reactors and Fuel Cycles

Contents

Introduction

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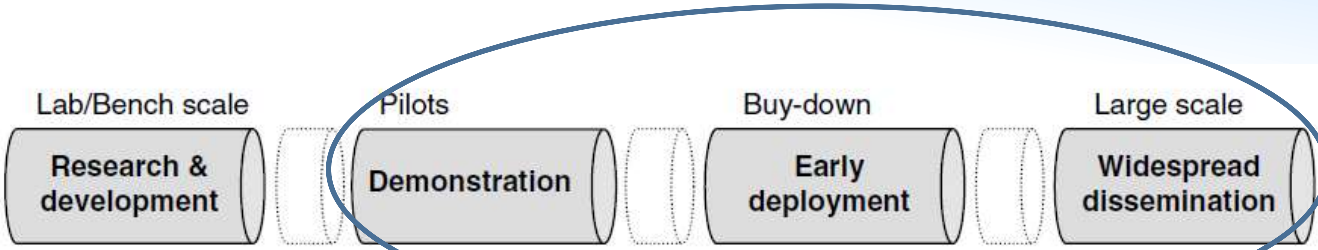
Many definitions for innovations

- **"Conversion of new knowledge into economic and social benefits."** *Source: EC Community Research & Development Information Service (2005), "A Glossary of Innovation Terms"*
- **"Successful entry of a new science or technology-based product into a particular market."** *Source: Branscomb, Philip and Auerswald, E. (2002), Between Invention and Innovation: An Analysis of Funding for Early-Stage Technology Development*
- **"A new or significantly improved product (good or service) introduced to the market or the introduction within an enterprise of a new or significantly improved process."** *Source: EC Eurostat (2004), Innovation in Europe: Results for the EU, Iceland and Norway – Data 1998-2001, Luxembourg*
- **"Commercially successful exploitation of new technologies, ideas or methods through the introduction of new products or processes, or through the improvement of existing ones."** *Source: OECD (2004), "Issues Paper & Background Paper – The International Conference on Innovation and Regional Development: Transition to a Knowledge-based Economy"*
- **"Implementation of a new or significantly improved product (good or service) or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations."** *Source: OECD and Eurostat (2005), Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd edition, Joint publication of OECD and Eurostat*

Common theme: introduction of a final beneficial "product" (invention vs. innovation)

Simplified stages of innovation *(OECD/NEA, Innovation in Nuclear Energy Technology, 2007)*



Adapted from Holdren, J.P. (1999), "Foundations of International Cooperation on Energy Innovation", Chapter 3 in *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation*. Washington, DC: Executive Office of the President of the United States.

Require significantly more effort than R&D

- Several actors are involved:
  - R&D institutions, Universities, Suppliers, Energy Providers, Government Institutions, Public, etc.
- The relationships/interaction between the above actors is important
- Environment characterized by Institutional frameworks, innovation infrastructure, management practices, nuclear legal framework, international commitments, etc
- Technical and institutional innovations are important for successful implementation of the final product

Public Acceptance is crucial if the final product is a nuclear facility (e.g., NPP, FCF, Disposal Facility, etc)

Nuclear Power Deployment Evolution (1/2)

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Generation I

Early Prototypes

Generation II

Commercial Power Reactors

Generation III / III+

Evolutionary Designs (Improvements to operating designs)

Generation IV

Innovative Designs

Innovative Nuclear Energy Systems

Past Innovations resulted in successful nuclear energy deployment today (however, not at the scale envisaged in the early years of nuclear)

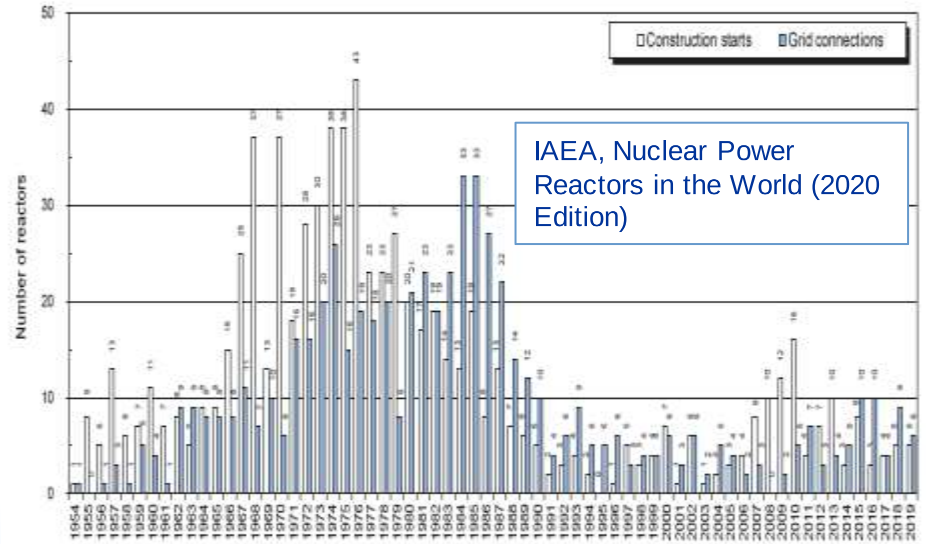
Potential for significant improvements (deployment and technology) to make meaningful contribution to sustainable development goals using current and future technologies

1950 1970 1990 2010 2030 2050 ………………………?

Nuclear Power Deployment Evolution (2/2)




Generation I | Generation II | Generation III / III+ | Generation IV



IAEA, Nuclear Power Reactors in the World (2020 Edition)

- Technical and institutional innovations resulted in successful early deployment
- Decline in later deployment can be attributed to several factors
  - Public Acceptance is a major factor (e.g., “perceived” risk following accidents, used fuel and HLW, security and proliferation concerns, etc)
- Improvements (innovations) to address public concerns focused on technology (e.g., improved safety features) and institutions (e.g., enhanced cooperation)
  - Should more be done in the area of institutional innovations to improve public acceptance?

1950 1970 1990 2010

Public Acceptance and Public Participation

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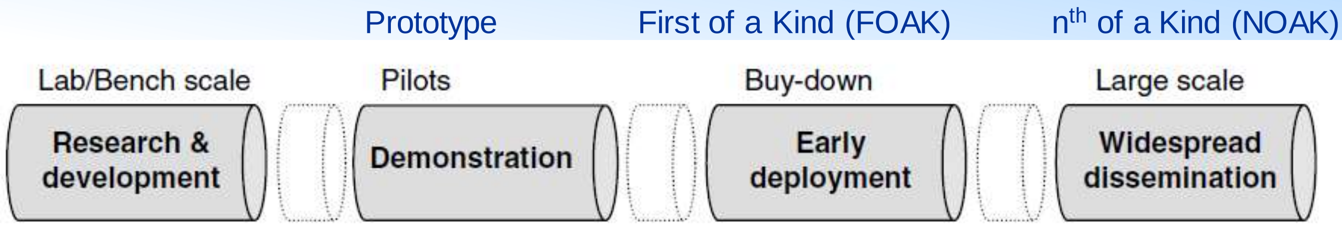
- Public Acceptance is a key issue (focus of this DF)
- Lots of information in the literature about public perception and acceptance of nuclear
    - Early days of nuclear vs. now
    - Perceived benefits vs. “real” benefits (do we really need nuclear?)
    - Perceived risk vs. “calculated” risk
    - Trust in nuclear industry and institutions
    - …etc
- Public participation in the process to deploy a nuclear facility is very important
    - Currently limited to certain aspects (e.g., citing of NPPs or disposal facilities, during licensing reviews)
- Should public participation be enhanced to cover more stages of the innovation process?
    - Familiarity at an early stage
    - Builds sense of ownership by the public?
    - Enhanced trust?
    - Other?



Adapted from Holdren, J.P. (1999), "Foundations of International Cooperation on Energy Innovation", Chapter 3 in *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation*. Washington, DC: Executive Office of the President of the United States.

- Example from the literature: incorporate public input in the design of a NPP
    - Take into consideration our knowledge of calculated and perceived risk in the design or design process
    - Goes beyond proposing better communication and education programmes
    - "Socially informed approach to design" to help address social concerns about NPPs

"Whilst there is no consensus in the literature, a review of these studies indicates that public support for nuclear is a determining factor in its diffusion, that public perception is dynamic and can be shaped by legitimate 'actors' and that transparency and stakeholder participation in the decision-making process are important"

Contents lists available at ScienceDirect
Energy Policy
journal homepage: www.elsevier.com/locate/enpol

Nuclear renaissance, public perception and design criteria: An exploratory review

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Contents lists available at ScienceDirect
Process Safety and Environmental Protection
journal homepage: www.elsevier.com/locate/psep

Public perceptions of design options for new nuclear plants in the UK

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Potential Future Nuclear Deployment Scenarios

- Can/should the incorporation of public input be extended to earlier stages of the innovation process?
- Or even before R&D stage to inform energy policies and to compare available energy options?
- Consider three “bounding” scenarios
  - Scenario I: Nuclear Power and fuel cycle options are implemented as they are today
  - Scenario II: Nuclear Power significantly increases to include electric and non-electric applications, and fuel cycle options evolve towards multirecycling
  - Scenario III: Nuclear Power is gradually phased out and final disposition strategies pending implementation

Adapted from presentation by Christophe XERRI, Director, Division of Nuclear Fuel Cycle, Waste Management, and Research Reactor (2019 International Conference on the Management of Spent Fuel from Nuclear Power Reactors)

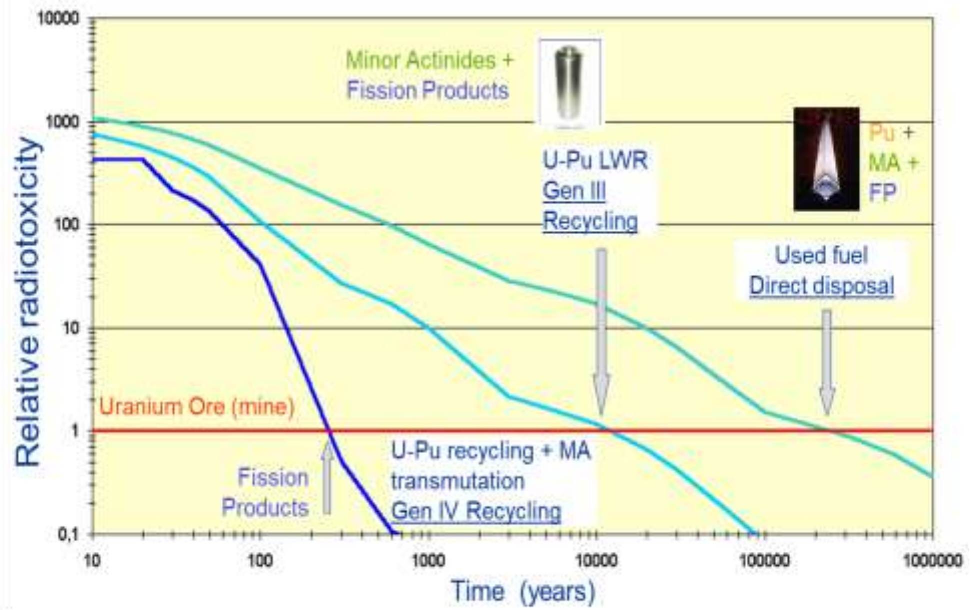
Scenario I

- Nuclear Power and fuel cycle options are implemented as they are today
  - Improved reactor designs
  - Advanced fuels (e.g., higher burnup, accident tolerant fuel, etc)
  - Enhancement of fuel cycle facilities safety and efficiency with final disposition routes in place
  - Disposal facilities for SF and HLW under operation
  - Some countries with small nuclear programmes using international services for recycling and possibly disposal
  - Political agreements between countries to build and deploy common facilities for waste management

Innovation has a role, especially for expanded deployment (necessary to address immediate climate concerns)

Scenario II

- Nuclear Power significantly increases to include electric and non-electric applications, and fuel cycle options evolve towards multirecycling
  - Advanced and innovative reactors deployed
  - Expansion into non-electricity markets
  - Environmentally friendly innovative fuel cycles
  - Fully closed fuel cycle (recycling valuable materials)
  - Natural resources preservation
  - Waste burden minimized
  - Flexible to adapt to any policy evolution
  - Multinational cooperation - fuel cycle front and backend



Innovation has a role; "preferred" scenario for sustainability and for meeting sustainable development goals

Scenario III

- Nuclear Power is gradually phased out and final disposition strategies pending implementation
  - SF accumulating in storage (mainly dry storage) at orphan sites
  - No or scarce support facilities for maintenance and re packaging if needed
  - Until final disposal, there is need for:
    - Ageing management programmes
    - Monitoring and inspection techniques
    - Knowledge preservation
    - Records preservation
    - Skilled professionals
    - etc

Innovation has a role to disposition remaining liabilities; international cooperation beneficial to countries adopting this scenario

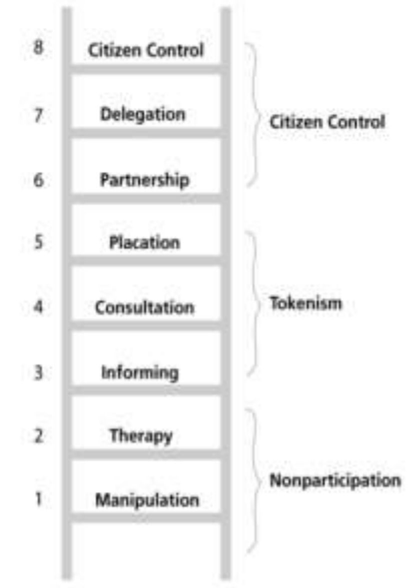
Technical and Institutional Innovations – Enhanced Public Participation

- Most likely the future will have a mix of the above scenarios
  - Public acceptance impacts which scenario is adopted
  - International cooperation between countries adopting any of the above scenarios is important for sustainability
- Innovation is required in all scenarios
  - Technical: improved and new innovative technologies
  - Institutional: cooperation arrangements, international instruments and conventions, harmonized practices, etc
- To what extent should the public be involved/informed?
  - Information usually provided on technical innovations to address certain public concerns (e.g., passive safety features of new reactors)
  - Is sufficient information provided to the public on related institutional innovations?
    - Would more information on institutional innovations (e.g., peer reviews for operating NPPs) enhance public acceptance?
  - Should public participation be enhanced?
    - e.g., early Participation (by the public) vs. providing information (to the public)
    - Participation in the decision-making process?
- Coordinated effort by all stakeholders necessary
  - Educational institutions can play a very important role (cover many disciplines, provide unbiased information, stable programmes, community trust, etc)

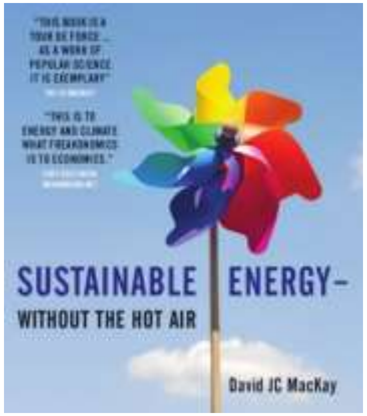
The Role of Educational Institutions

Examples

- Exploring mechanisms for enhanced public participation
  - Learning from other industries and institutions
  - “Mini publics” – innovative mechanism for the public to deliberate on a wide range of issues
- Providing unbiased information to the public
  - e.g., pros and cons (and limits) of various energy sources as part of energy system studies. Could address perceived benefits and perceived risks of nuclear (and other energy sources)
- Providing innovative educational tools to address key public concerns (e.g., fear of radiation)
- And many more!
- Coordinated effort (nationally, regionally, globally)



Arnstein's Ladder (1969)
Degrees of Citizen Participation



Conclusions

- Innovation has always had a role and will continue to have a role in nuclear energy deployment
  - Public acceptance has a major impact on nuclear deployment
- Public concerns can be addressed through technical and institutional innovations
  - Should public participation in both aspects be enhanced?
    - Partners in decision making process?
    - Can we learn from other industries and institutions?
  - Should public participation during the early stages of the innovation process be explored?
- Educational institutions can play a major role

Thank you for your attention
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