Economic Indicators to Assess Benefits from Cooperation Among Countries

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International Atomic Energy Agency

Overview

Preamble: PESS and its mandate

1. Context: Innovation and economics
2. Indicators of creation of new knowledge
3. Deployment: barriers and remedies
4. Summary and conclusions

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Preamble: PESS and its mandate

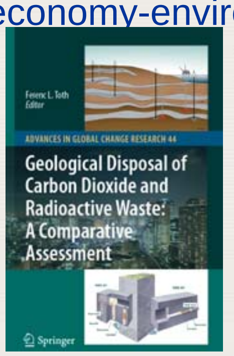
DDG-NE: Planning and Economic Studies Section

1) Planning and Capacity Building Unit

Develop & disseminate models, train experts, apply in TC on national energy strategies; INIG: Pre-feasibility

2) 3E Analysis Unit (Energy-economy-environment)

- *Technoeconomic analyses*
- Geologiocal disposal of RW and CO2: workshop, book, CRP
- CC and energy systems: same
- NP - sustainable development
- Life cycle emissions (CO2/GHG)



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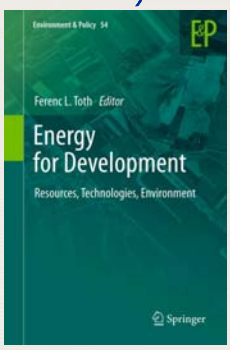
3

Preamble: PESS and its mandate

2) 3E Analysis Unit (Energy-economy-environment)

- *Sustainable energy development*
- CC and Nuclear Power: Annual
- *Indicators* for NE Development (INED)
- Book: Energy for Development
  IAEA Scientific Forum
- UN & others: IPCC LAs in WGII, WGIII AR4, AR5, SREX
- UN CSD: Rio+20 Conference



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4

1. Context: Innovation and economics

Schumpeter:

Invention: new idea:

science – basic research – public good – public finance

Innovation: marketable products/processes:

applied science – targeted research – private good (patents) – private finance

Diffusion: spread across markets → impact on economy and society

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5

1. Context: Innovation and economics

Stages in technological R&D&D&D
to Commercial Utilization:

Basic research: discoveries (materials sci, chemistry,)

Applied research: inventions, improvements

Development: producing working prototype

Demonstration: testing, scaling up, proving feasibility

< “valley of death” >

Deployment: implementation in pre-commercial stage

Commercial utilization: widespread use, diffusion

Reality: overlaps, iterations, feedbacks between stages

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6

1. Context: Innovation and economics

Nuclear industry – current challenges:

- Operation safety
- Waste disposal – resource use
- Proliferation, diversion of N material
- Costs, competitiveness

➔ Public acceptance

Globally shared concerns

– global cooperation to find solutions

AND: Globally shared opportunities:

need for low-C tech, supply security, price stability, etc.

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1. Context: Innovation and economics

R&D stage	Type of TD
Basic research	science-driven innovation
Applied research	science-driven + ITC
Development	induced technology change
Demonstration	induced technology change
Deployment:	learning by doing, some ITC
Commercial utilization	LbD

LbD: learning/experience curves, cost-free < happens>

ITC: triggered by relative prices (direct/indirect); requires investments (costs); knowledge capital explicit/tacit; <pulled>

funds largely private sources, depends on appropriability

SDI/TC: generated by public S&T policy <pushed>

fostered by public R&D funding, creating public good

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1. Context: Innovation and economics

Point #1:

Generic patters of technological R&D cycle →

need to be adopted to special features of SNES

Type of TD in R&D stages:

funding requirements: magnitude, source (priv/pub)

knowledge generated: public or proprietary

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2. Indicators of creation of new knowlege

SNES: NPR and NFS – develop simple models and indicators

Here example:

Indicators Based on Creation of New Knowledge

Input and Output

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2. Indicators of creation of new knowledge

[CRE-I1] (inputs) intramural R&D *expenditures* by sector of performance, by source of funds, and by type of R&D

[CRE-I2] (inputs) extramural R&D *expenditures*

[CRE-I3] (inputs) government funded R&D *expenditures*

[CRE-I4] (inputs) the number of R&D *researchers* and technicians in the field

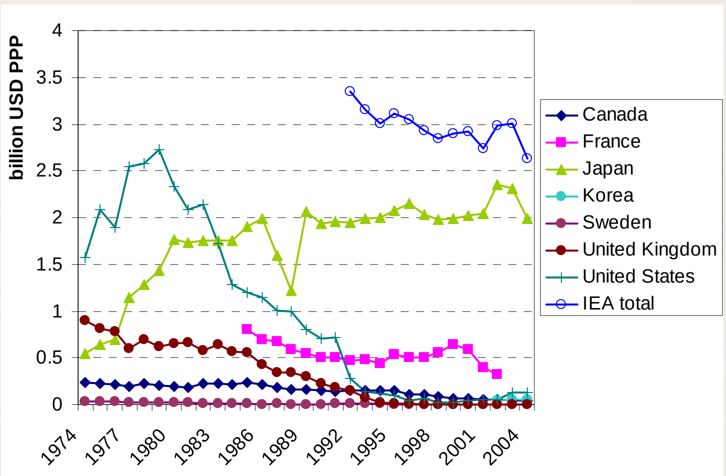
[CRE-I5] (inputs) number of research-purpose *reactors* being used

[CRE-O1] (outputs) number of scientific *publications* in field

[CRE-O2] (outputs) number of *patent* in the field

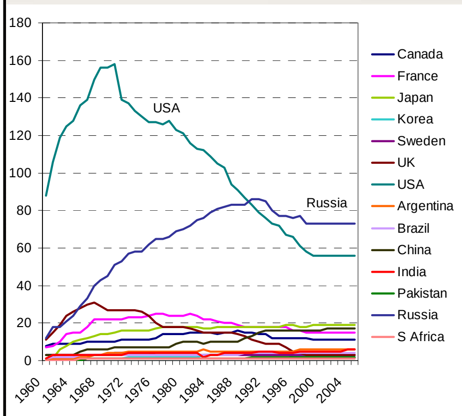
2. Indicators of creation of new knowledge

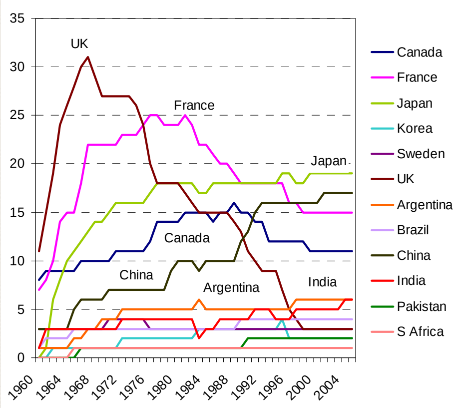
CRE-I3: Gov't-funded R&D on nuclear fission



2. Indicators of creation of new knowledge

CRE-I5: Number of research reactors used





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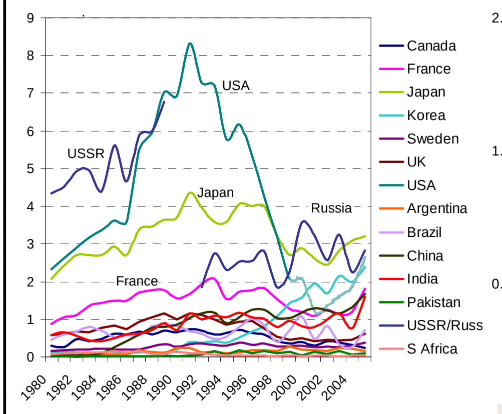
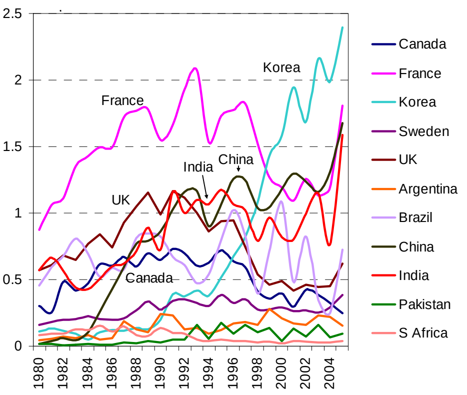
2. Indicators of creation of new knowledge

CRE-O1: Scientific publications in nuclear power and associated fuel cycle field (1000s)





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2. Indicators of creation of new knowledge

NP and FC: work in progress; so far: vast data problems (private)
What are the meaningful input and output indicators?
Obvious place to start: anything usable from ITC representation?
Broader approach: R&D allocation for SD (N)energy innovation
Portfolio models: for competing ideas/directions: IF reasonable (gu)es(s)timates of funds needed, probability of success, time required, value of outcome
Game theory models: technologies, probabilities, payoffs
EneTech models: hypothetical technologies → total system cost; many sensitivity runs + exog estimates of R&D investment needs → identify promising directions
Real challenge: how to model discoveries and true inventions (no one knows today) – futures studies surprise methods?

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2. Indicators of creation of new knowledge

Point #2: models of SD innovation are needed
Options to include results into general economic (CGE) or energy sector (PE) models: depend on model type & detail
Highly aggregated: one parameter or one equation
More detailed: reduced form representation of SDI model
Initially: improving existing parameters, adding new ones – exogenous (simple but does not account for costs)
Later: new equation, knowledge multiplier (more explicit but requires understanding of technology outcome: remote from SDI)

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3. Deployment: barriers and remedies

Recall: scheme of technological R&D&D&D to CA

Deployment: implementation in pre-commercial stage

Commercial utilization: widespread use, diffusion

Reality: overlaps, iterations, feedbacks between stages

Regional cooperation: in deployment and CA phases

→ closer look at deployment

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17

3. Deployment: barriers and remedies

Across stages of technology development process:

Funding: magnitude increases; Depl: jump, varies widely

Objectives: more focused; Depl: THE technology as demonstrated by the prototype

Sources: more concentrated; Depl: owners, later imitators

and: public-private shares shift towards private

Note: general patters, but: variations across technologies, exceptions, special cases

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18

3. Deployment: barriers and remedies

Deployment: beginning of commercial distribution

SNES demonstrated, potential for competitiveness promising but: barriers → What is special about SNES?

General technology R&D outcomes:

reduce (priv) costs, increase quality of product/service

→ users adopt them when $B_n/C_n > B_o/C_o$:colour tv, cell

SNES: may or may not do the above, but:

- deliver public good (energy supply security)
- mitigate an externality (GHGs)
- other benefits, but: remote in time, magnitude of investmts

Barriers: analyze → understand→ alleviate; not always $$

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3. Deployment: barriers and remedies

Barrier 1: Cost

Problems: public-good features of SNESs not valued, externalities of competitors not penalized

Indicators: econ.value of supply security, soc.cost of C

Remedies: performance standards, portfolio requirement

Problems: early phase of the experience curve → realistic expectations for cost reductions from LbD

Analytical tools: life cycle (S-curve) and learning curve →use them as monitoring tools (not prediction tools)

Remedies: direct support, public procurement, technology transfer assistance

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3. Deployment: barriers and remedies

Life cycle (S-curve): penetration (volume, market share)

once new T starts picking up (annual increase in V or MS): → start reducing direct support

Learning curve (experience): unit cost reduction per doubling cumulative production

once unit costs start approaching those of incumbent technologies → start reducing direct support

In contrast: if no learning despite deployment (flat or sluggish learning curve) → shift private investment and public support back to R&D: improve cost, performance

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3. Deployment: barriers and remedies

Barrier 2: Market structure

Problems: monopolistic/oligopolistic market, entry barriers, inertia

Indicators: number of sellers (tech. owners/providers)

market shares of largest, 3-5 largest sellers (>50%?)

diversity index:

Shannon-Wiener Index (SWI):

$$SWI = -\sum_i X_i \ln X_i$$

X_i: the market share of supply source i

Remedies: direct intervention: market share targets; information to distributors and consumers;

go for niche markets

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3. Deployment: barriers and remedies

Barrier 3: Capital stock inertia

Problems: slow turnover of capital stock, old stock largely depreciated: $MC_o < MC_n$; more lucrative to refurbish old than to install new

Indicators: absolute/relative weighted average/mean age

(relative to econonomic/technical life)

performance (efficiency) weighted average age

Remedies: pre-announced dynamic performance standards: improve or retire;

direct subsidy for retirement of old capacities

→ Not clear how these would work for SNES

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3. Deployment: barriers and remedies

Barrier 4: Infrastructure

Problems: incompatibility with existing storage, distribution, delivery equipment and networks, or: infrastructure does not exist

Indicators: ??

Remedies: direct public investment or indirect support to private investments to develop infrastructure;

ratio depends on public/private nature of T

Problems: special features of T; eg, release, proliferation

Remedies: R&D in SNES itself or infrastructure to handle special features

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3. Deployment: barriers and remedies

Barrier 5: Regulation

Problems:

- inadequate/incompatible planning and licensing procedures, standards, etc.

Indicators: ??

Remedies:

- regulatory innovation; updating standards
- flexible and adaptive regulatory regimes

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3. Deployment: barriers and remedies

Barrier 6: Public acceptance

Problems:

- ignorance, outdated or spurious information, justified or unfounded fears, NIMBY

Indicators: self-reported knowledge, factual knowledge, public attitude, willingness to participate in DM

Remedies:

- labeling, performance indicators, information provision, economic and social incentives for host regions

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3. Deployment: barriers and remedies

Barrier 7: Financing

Problems:

gap between economic and financial Cs/Bs of SNES

transaction costs: Ts delivered in smaller projects: transaction costs higher, but value at risk smaller

and: risks pooled from several projects → lower premia

risks: T itself, costs, market, regulatory, public acceptance: diverse and different depending on T

Indicators: many; relevance/choice depends on context of application

Remedies: direct or indirect financial support; innovative FIN schemes, PPPs, venture capital

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3. Deployment: barriers and remedies

Point #3:

Importance of deployment: the probe of the pudding …

from technical feasibility to economic viability to commercial competitiveness

but: if the probe fails, trouble may be elsewhere: barriers

Barriers: often not cost or investor disinterest; 7 types

Barriers: more R&D may or may not help to alleviate them

Proper ratios of R&D vs Deployment costs are difficult to estimate: number and intensity of iterations across phases of the R&D cycle differ widely across technologies AND: cross-fertilization from other T: e.g., isotopes

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3. Deployment: barriers and remedies

Point #3 cont:

Precondition to deployment: solid demonstration units (expensive and limited learning from units quasi-permanently down)

Potential pitfalls in deployment support:

- too early provision: lock-in immature T, block more promising ones
- too early phase-out: drop a potentially useful T
- too late phase-out:
  IF T successful: distort market competition
  IF T unsuccessful: throw good money after bad
- S-curves and learning curves: useful monitoring and assessment tools in balancing R&D vs deployment

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4. Summary and conclusions

Nuclear industry: most interconnected globally

esp. negative events: anywhere → impacts everywhere

Joint concerns: proliferation resistance to resource availability

Implication: combination of competition and cooperation

in innovation/R&D to operation (WANO)

and international organizations and projects:

IAEA, OECD NEA, GIF, many others

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30

4. Summary and conclusions

Costs and competition:

- with other resources/technologies: fossil, renewables
- among NP technologies: LWR vs FR now

increasing complementarity in the future (CFS FR)

Innovation: SNES concepts – need for basic research

→ public good, collaboration (free riders?)

Innovation: SNES designs – development & demo:

→ public good, collaboration (free riders?)

Innovation: SNES PPs – demonstration & deployment:

→ private good, competition

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4. Summary and conclusions

Innovation in NE:

imperative: safety and proliferation resistance

necessary: economics and sustainability

→ Complex multi-attribute problem: all necessary

Economics of innovation: increase efficiency by

international cooperation in R&D&D&..?

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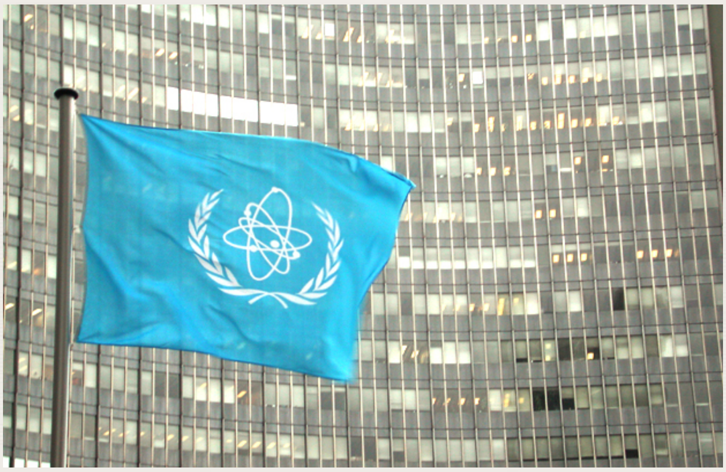
http://www.iaea.org/OurWork/ST/NE/Pess/



…atoms for peace.

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33