2372-33

Joint ICTP-IAEA Workshop on Sustainable Energy Development: Pathways and Strategies after Rio+20

1 - 5 October 2012

Innovation in the Nuclear Industry: International Perspectives

Ferenc L. Toth
IAEA, Vienna
Austria

Innovation in the Nuclear Industry: International Perspectives

Ferenc L. Toth

Planning & Economic Studies Section (PESS)

Department of Nuclear Energy

IAEA-ICTP Workshop on

"Sustainable Energy Development: Pathways and Strategies after Rio+20"

ICTP, Trieste, Italy, October 1-5, 2012

IAEA

International Atomic Energy Agency

“If at first, the idea is not absurd,
then there is no hope for it.”

(Albert Einstein)

Overview

1. Context: Innovation and economics
2. IAEA – INPRO
3. GIF
4. Summary and conclusions

IAEA

1. Context: Innovation and economics

Schumpeter: Invention – Innovation – Diffusion – extend:

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

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

IAEA

1. Context: Innovation and economics

Generation I

Early prototype reactors

- Shippingport
- Dresden, Fermi I
- Magnox

Generation II

Commercial power reactors

- LWR-PWR, BWR
- CANDU
- VVER/RBMK

Generation III

Advanced LWRs & HWRs

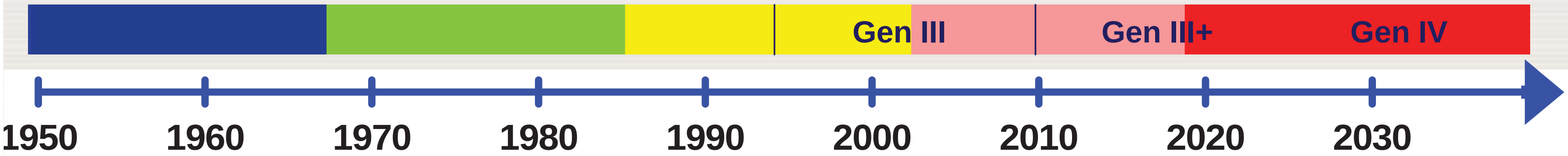
- AP1000, ABWR, System 80+
- ACR
- EPR

Generation III+

Evolutionary designs with improved economics and safety for near-term deployment

Generation IV

- Highly economical
- Enhanced safety
- Minimal waste
- Proliferation resistant



2. IAEA - INPRO

International Project on

Innovative Nuclear Reactors and Fuel Cycles:

- global forum on innovative NESs and deployment
- international studies and collaborative projects

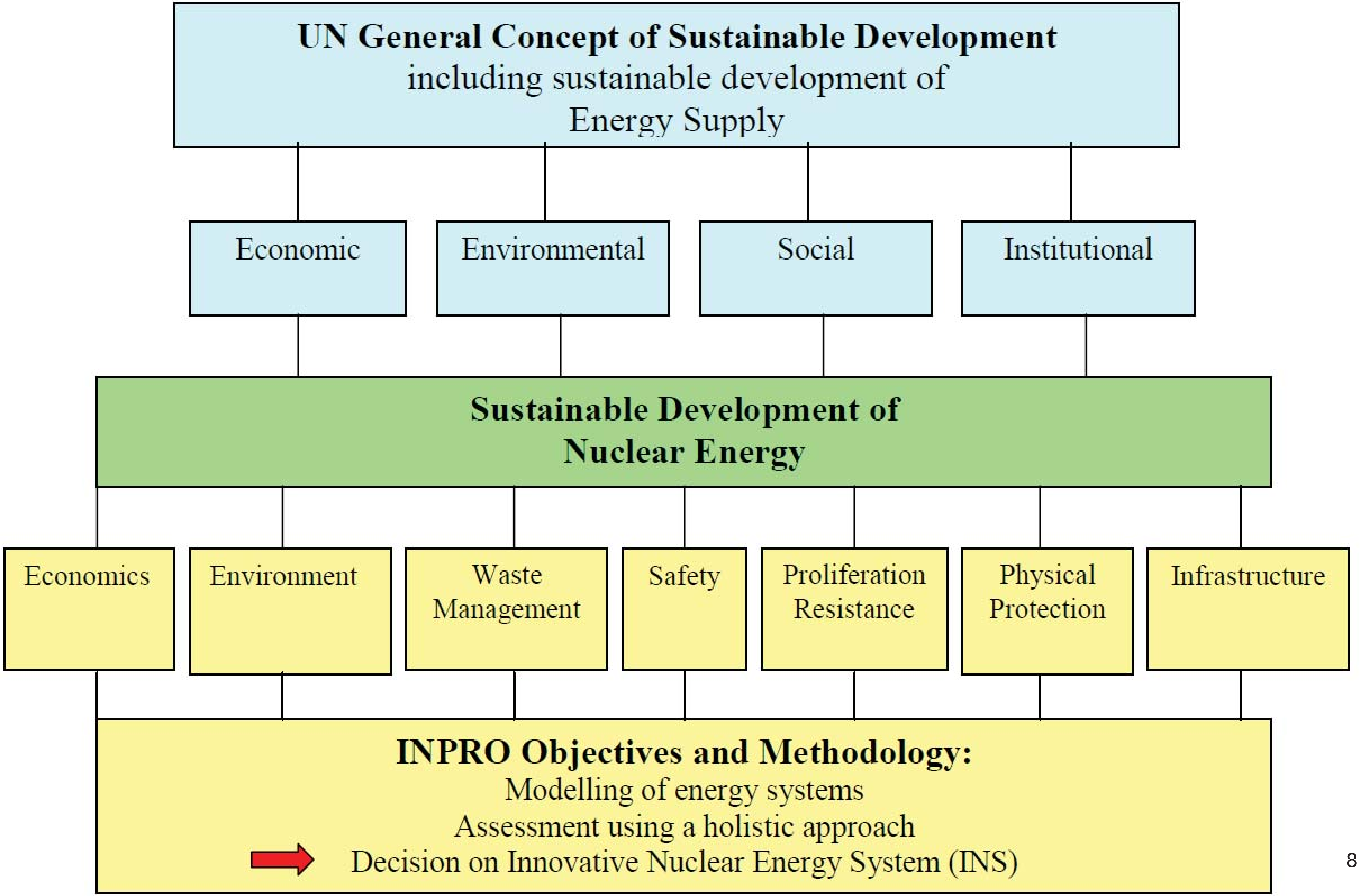
Foster innovation & sustainable NE development

Help MSs assess sustainability of existing/planned NES

→ linked to national energy strategy/planning

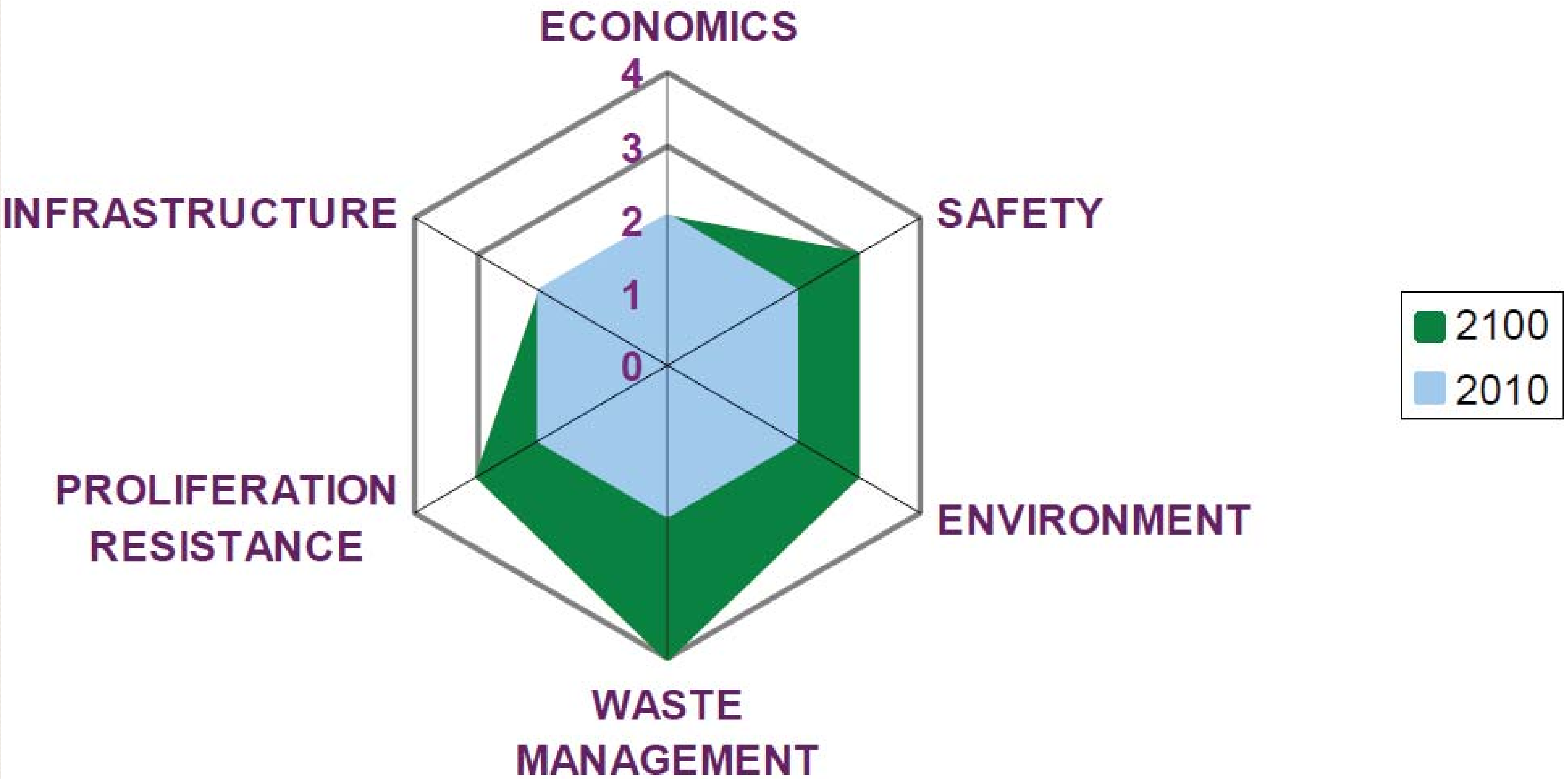
→ related to broad sustainability

2. IAEA - INPRO


UN General Concept of Sustainable Development
including sustainable development of
Energy Supply
Economic
Environmental
Social
Institutional
Sustainable Development of
Nuclear Energy
Economics
Environment
Waste Management
Safety
Proliferation Resistance
Physical Protection
Infrastructure
INPRO Objectives and Methodology:
Modelling of energy systems
Assessment using a holistic approach
Decision on Innovative Nuclear Energy System (INS)

2. IAEA - INPRO

synoptic assessment , comparison, directions



2. IAEA - INPRO

Application: Joint Studies – here: CNFC FR

Closed Nuclear Fuel Cycle with Fast Reactors

Resource: practically inexhaustible

Environment: avoid mining and enrichment

Waste: reduced volume, heat load, radiotoxicity

Safety: meets current standards

Proliferation resistance: higher

Infrastructure: needs international arrangements

Economics: not yet competitive with thermal or fossil

3. GIF

Generation IV International Forum:

collaborative effort to develop next generation NESs

4 areas - 8 technology goals:

Sustainability: environment, resource, waste

Economics: cost advantages, comparable financial risk

Safety and reliability: of operation, very low likelihood and degree of reactor core damage, eliminate the need for offsite emergency response

Proliferation resistance and physical protection: unattractive for diversion, protection against terrorism

IAEA

3. GIF

Objectives widely shared → international R&D progr.

Members: 12 countries + Euratom

Target: market deployment from 2030

Process: review and select reactor systems, related R&D plans and framework agreements

Now: System agreements – specific R&D projects for 6 GIF systems

and: cross-cutting issues, common to all systems:

Proliferation Resistance and Physical Protection; Economic modeling; Risk and Safety

3. GIF (Source: gen-4.org)

System	Neutron spectrum	Coolant	Temp. °C	Fuel cycle	Size (MWe)
VHTR (Very high temperature gas reactor)	thermal	helium	900 to 1000	open	250-300
SFR (Sodium-cooled fast reactor)	fast	sodium	550	closed	30-150, 300-1500, 1000-2000
SCWR (Supercritical water-cooled reactor)	thermal/ fast	water	510-625	Open/ closed	300-700 1000-1500
GFR (Gas-cooled fast reactor)	fast	helium	850	closed	1200
LFR (Lead-cooled fast reactor)	fast	lead	480-800	closed	20-180, 300-1200, 600-1000
MSR (Molten salt reactor)	epithermal	fluoride salts	700-800	closed	1000

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, GNEP, many others

5. 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: Gen IV concepts – need for basic research

→ public good, collaboration (free riders?)

Innovation: GEN IV designs – development & demo:

→ public good, collaboration (free riders?)

Innovation: GEN IV PPs – demonstration & deploymt:

→ private good, competition

5. 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&..?

IAEA

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

…atoms for peace.

IAEA