

9th GIF/INPRO-IAEA Interface Meeting
IAEA HQs, Vienna, Austria. 4-5 March 2015

INPRO methodology in the area of Environment (Stressors and Resources)

F.Depisch, S.Fesenko, A.Korinny

IAEA/INPRO group



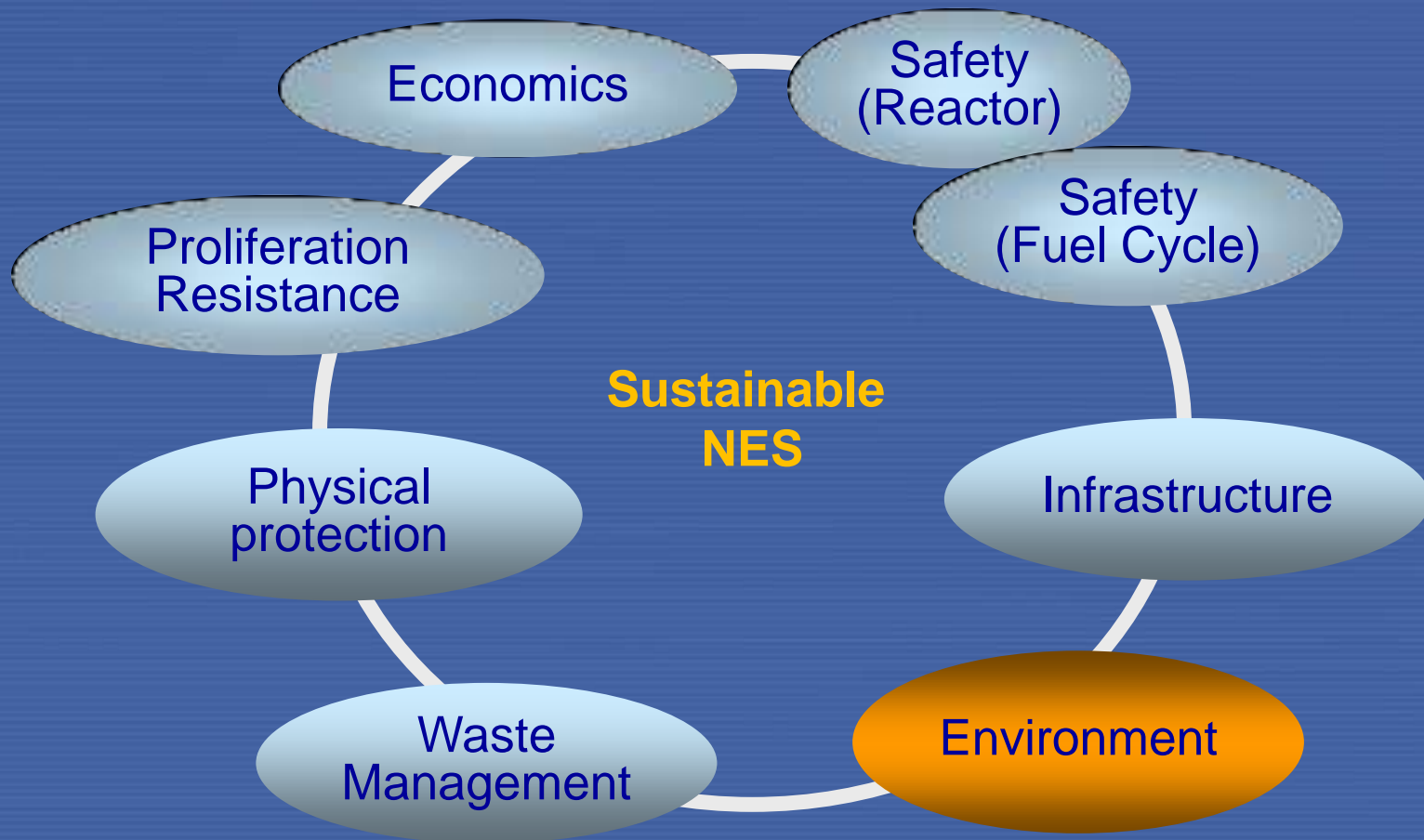
IAEA

International Atomic Energy Agency

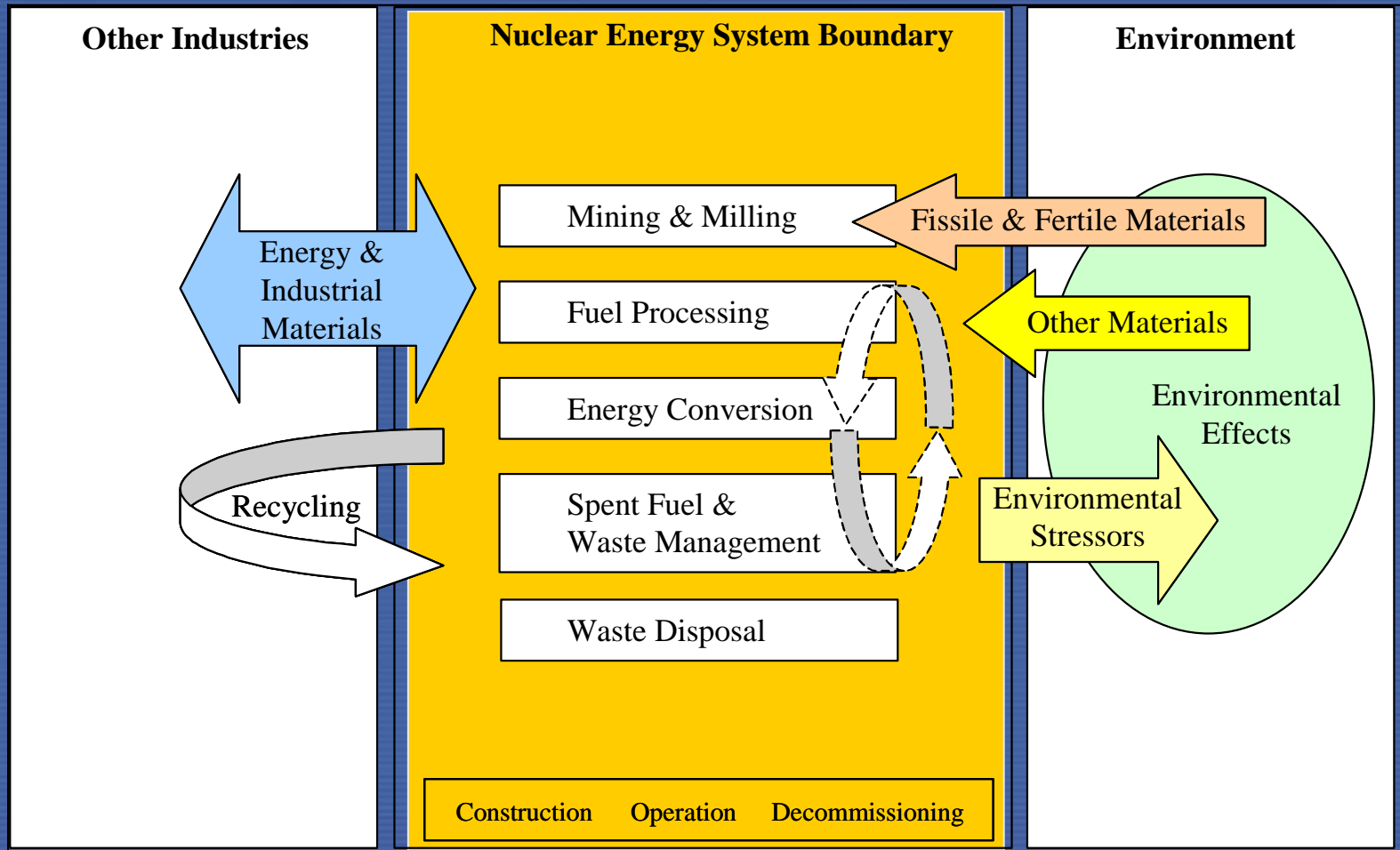
Introduction: INPRO areas in 2008-2014



INPRO
International Project on
Innovative Nuclear Reactors
and Fuel Cycles



Interfaces of Nuclear Energy System



Environment includes:

- Human beings & Non-human biota;
- Abiotic components, including soil, water and air;
- Natural resources and landscape;
- Interactions among these components.

Environmental effect definition includes detrimental change of environment:

- Physical, chemical or biological change;
- Health effects on people, plants and animals;
- Effects on quality of life;
- Depletion of resources.

Stressor definition includes entities that can induce an adverse response in the environment:

- Physical, Chemical, or Biological effect;
- Radioactive & non-radioactive emissions to air, water (fresh and groundwater) and soil;
- Waste heat discharges;
- Land use.

INPRO area of environment structure in 2008-2014



INPRO
International Project on
Innovative Nuclear Reactors
and Fuel Cycles

Basic Principle BP1: Acceptability of expected adverse environmental effects

Two User Requirements:

- **Controllability** of environmental stressors;
- Adverse effects **as low as reasonably practicable**.

Basic Principle BP2 : Fitness for purpose.

Two User Requirements:

- Consistency with **resource availability**;
- Adequate **net energy output**.

Nine criteria covering all aspects of those four URs.

Update of INPRO methodology in the area of environment

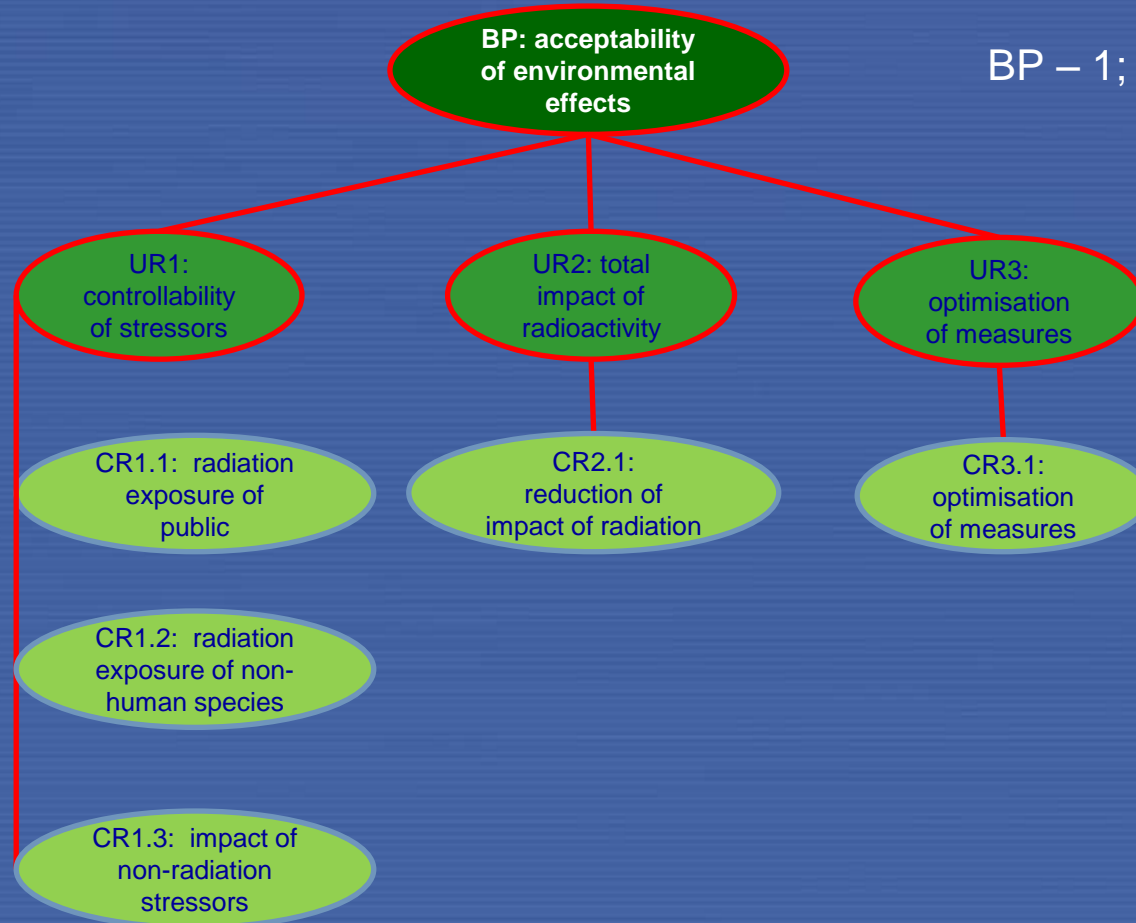


INPRO
International Project on
Innovative Nuclear Reactors
and Fuel Cycles

- Area of Environment was requested to split into two separate areas:
 - Environmental **impact of stressors**;
 - Environmental impact from **depletion of resources**.
- **Structure** of INPRO requirements in these two areas has been modified for better transparency and flexibility;
- Introduced separate criteria on:
 - Adverse effects of **non-radiological stressors**;
 - Effects of stressors on **non-human biota**.
- In 2014 both reports approved for publication as Nuclear Energy Series Reports NG-T-3.13 and NG-T-3.14;

Impact of stressors

Environmental impact of stressors: structure



INPRO assessment of environmental impact of stressors is focused on:

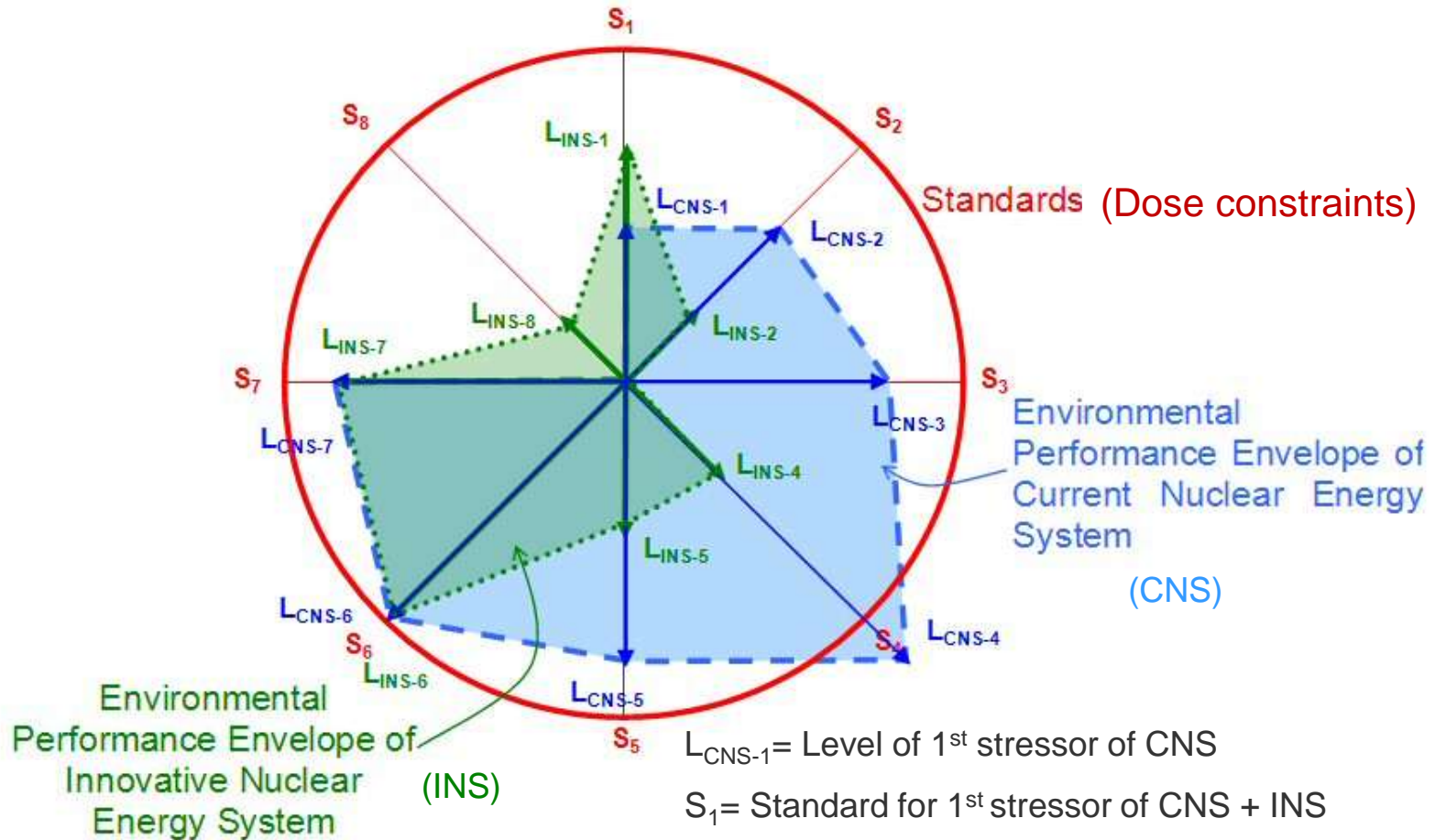
- Screening of single facilities within a given NES option:
 - Mining and milling facilities;
 - Refining and conversion;
 - Enrichment;
 - UOX and MOX fabrication;
 - NPP and spent fuel storage;
 - Reprocessing;
 - Waste disposal (discussed in INPRO manual on Waste Management).
- Normal operation, including off-normal events (AOO):
 - no accidents considered in this area.

Impact of stressors: groups of stressors and limits



Stressors	Units	Limits
Radionuclides		
Emission Rate	Bq/s	Reference Level (Control Level)
Total alpha/beta activity	Bq/m ³	National Limits
Radionuclide activity in air, water	Bq/m ³	Limits based on radiation safety level
Dose to the population	mSv/a	National Limits
Doses to reference biota species	mGy/a	Limits based on international consensus
Toxic chemicals		
Heavy metals	kg/m ³	National Limits
Organic compounds	kg/m ³	National Limits
Others		
Land committed	m ² /tU(or GW)	National Limits
Particulates to air	g/m ³	National Limits
Waste heat to air / water	MW(h)/a	National Limits
Solids to water	g/m ³	National Limits

Impact of Stressors: controllability

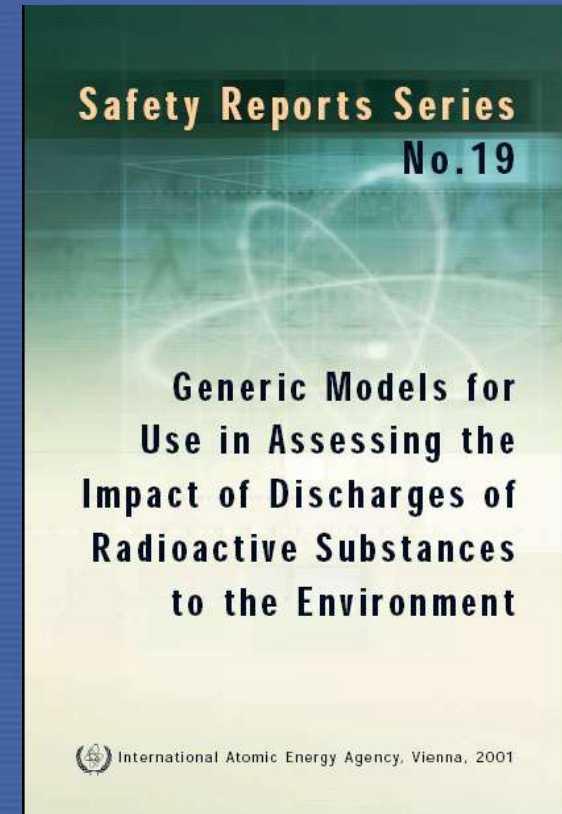


Impact of stressors: simplified evaluation model

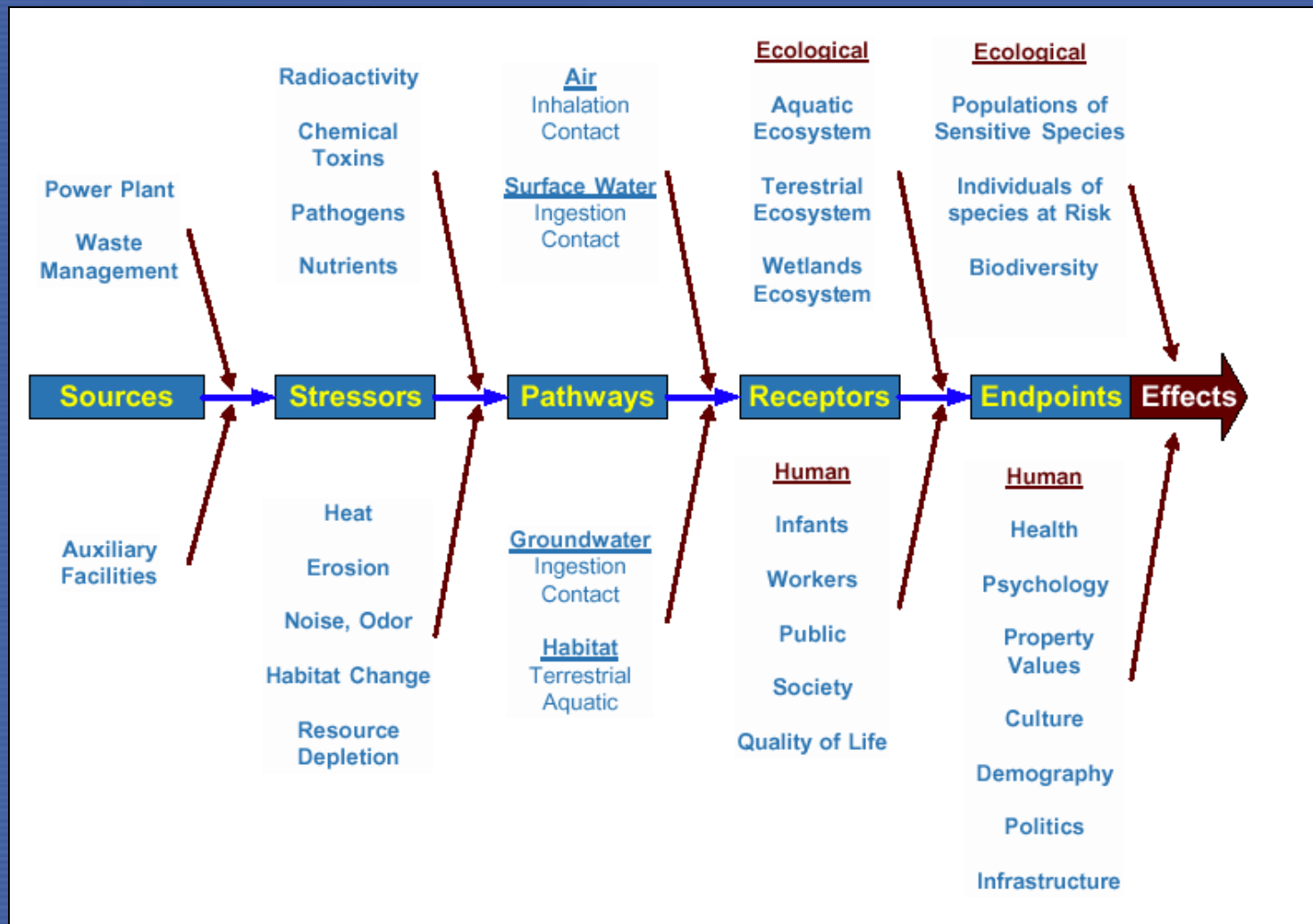


INPRO
International Project on
Innovative Nuclear Reactors
and Fuel Cycles

- Simplified IAEA evaluation method for radiological stressors (tiered approach) based on IAEA Safety Reports Series No.19;
- IAEA models “developed for screening of proposed radioactive discharges of new facilities”;
- Preliminary evaluation of radiological effects on humans to be compared with dose limits;
- New edition of report is expected soon.



Impact of stressors: analysis of impact on environment



INPRO basic principle in the area of impact of stressors



- BP: The expected **adverse environmental effects** of a nuclear energy system shall be well within the performance envelope of current nuclear energy systems delivering similar energy product
- Three user requirements:
 - **Controllability of environmental stressors:** The environmental stressors from each facility of a NES over the complete life cycle should be controllable to levels meeting or below current standards;
 - **Reduction of total environmental impact of emitted radioactivity:** Total radiotoxicity* of radionuclides discharged by the NES assessed should be lower than that of any current NES delivering similar energy products;
 - **Optimisation of the measures to reduce environmental impact:** The measures applied to reduce adverse environmental impact attributable to a NES should be optimised

Note: * - Ability of radionuclides to cause harmful effects because of its radioactivity

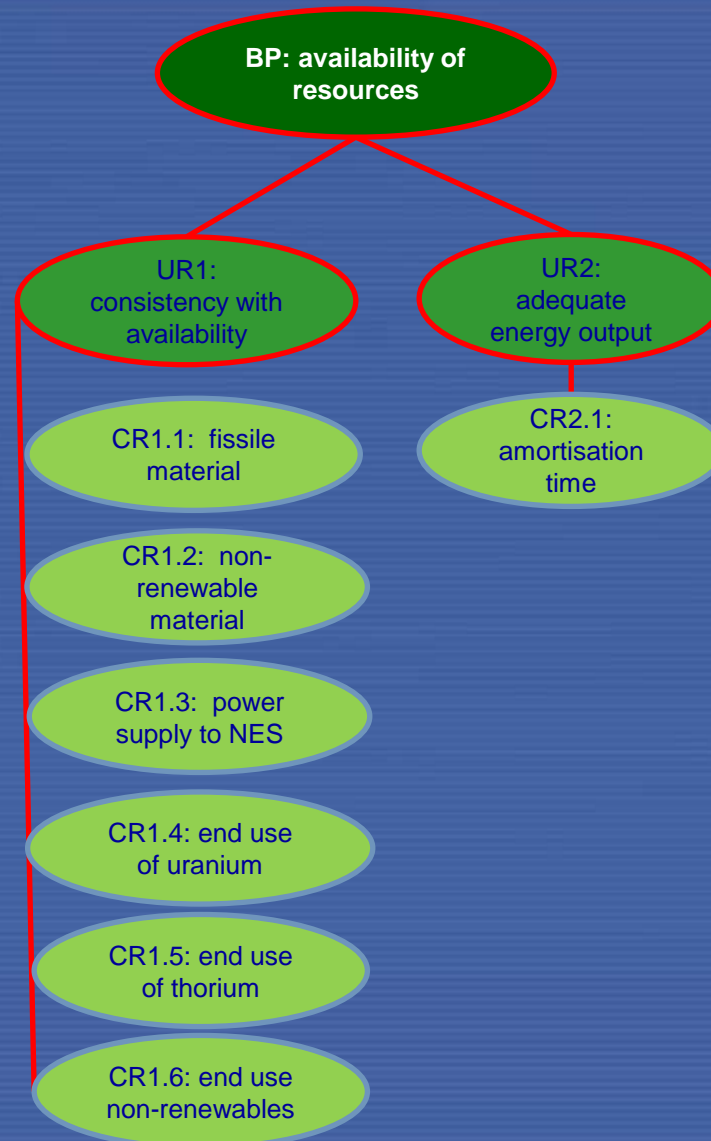
INPRO criteria in the area of impact of stressors



- **Dose to public** should be lower than dose constraints (may vary for different facilities and countries, examples provided);
- Doses to the reference **biota species** should be lower than international recommendations (1 mGy/day recommended);
- Levels of **chemicals and other stressors** should be lower than national environmental safety standard levels;
- **Total radiotoxicity** of radionuclides emitted to the environment from the NES assessed should be lower than radiotoxicity of stressors emitted to the environment from current NES delivering similar energy products;
- Measures to reduce environmental impact of the NES should be **optimised**. Options:
 - Best Available Techniques (BAT);
 - Best Environmental Practice (BEP),
 - Best Available Technology Not Entailing Excessive Costs (BATNEEC),
 - ALARA or ALARP

Depletion of resources

Environmental impact from depletion of resources: Structure



BP – 1; UR – 2; CR – 7

INPRO basic principle in the area of depletion of resources



- BP: A nuclear energy system shall be capable of contributing to the energy needs in the 21st century while making **efficient use of non-renewable resources**
- Two user requirements:
 - **Consistency with resource availability:** The NES should be able to contribute to the world's energy needs during the 21st century without running out of fissile/fertile material and other non-renewable materials, with account taken of reasonably expected uses of these materials external to the NES. In addition, the NES should make efficient use of non-renewable resources
 - Three types of resources considered: fissile materials, power supply and non-renewable resources (e.g. zirconium).
 - **Adequate net energy output:** The energy output of the NES should exceed the energy required to implement, operate and decommission the NES within an acceptably short period.

INPRO criteria in the area of impact of depletion of resources



- **Fissile/fertile material** available for use in the NES should be enough at least for 100 years;
- **Non-renewable materials** available for use in the NES should be enough at least for 100 years;
- **Power available** (from both internal and external sources) for use in the NES should be enough at any period of time within next 100 years;
- **End use**, i.e. energy delivered by the NES per Mg, of uranium mined should be higher than maximum achievable end use for an existing (2013) NES with a once through (open) fuel cycle;
- **End use of thorium** mined, should be higher than maximum achievable end use for a current operating thorium fuel cycle;
- Limits for **end use of non-renewable** materials should be determined on a case specific basis;
- **Time required to match the total energy input** into the NES with energy output \ll intended life time of NES

Conclusion



- INPRO methodology covers two aspects of environment:
 - Impact of stressors on environment;
 - Depletion of resources in the environment.
- INPRO methodology offers using simplified method to perform sustainability assessment in the area of impact of stressors;
- INPRO methodology asks for availability of resources at least until the end of the century.



Thank you for your attention!

www.iaea.org/INPRO a.korinny@iaea.org