Economics of Radiation Processing Technology: Posers and Prospects

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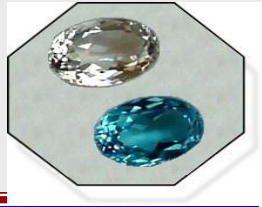
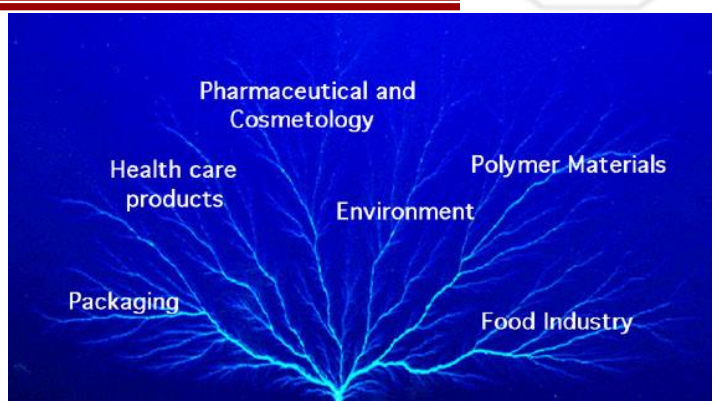
Preamble, Scope & Disclaimer

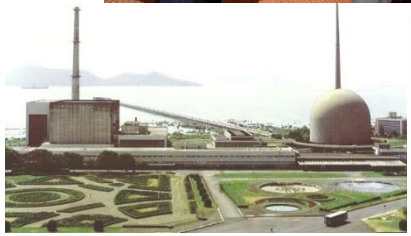


- Background information
- Analytical perspectives for consideration
- Factors impacting economics
- Need for sustainability of services and benefits



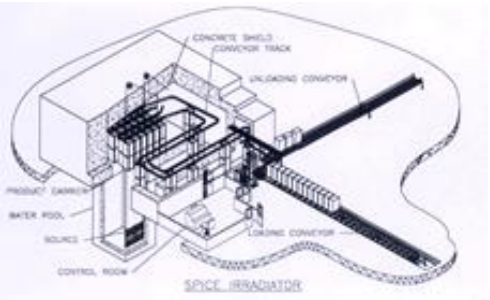
info basis: Ex-Chmn. & CE, BRIT; Ex-Assoc. Director Isotope Group, BARC; Ex-Director of NAPC-IAEA; Chair of AERB's Safety Review Committee for Applications of Radiation

- Professional views
- Not representing DAE-BARC / IAEA
- No sponsors; No conflict of interest



Radiation Processing Applications: Classification *(1 of 2)*

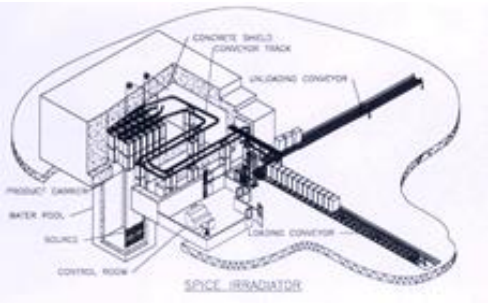
- Radiation-aided '***sanitisation***' of exposed materials (e.g. 30-50Gy; 1-12kGy; 25kGy)
- Radiation-aided '***designer-modifications***' of exposed materials (kGy to MGy used)
- **Established** industrial use
- **Proven** and Growing
- **Demonstrated**, yet to enter large use
- **Emerging** trends + Tech. Dev. stage



Radiation Processing Applications: Classification *(2 of 2)*

- **Established** and in regular industrial use:
  e.g. sterilization of medical products; cross-linking of wire and cable insulation; surface curing; hygienisation of food and agricultural products; xx

- **Proven** and Growing: e.g. material modification → advanced materials; polymers, grafts, coating, …



- **Demonstrated**, yet to enter large/routine use: e.g. flue gas treatment; wastewater treatment; sewage sludge treatment

- **Emerging** trends + Tech. Dev. stage: e.g. 'designer' materials, incl. on nanoscale (gels, particles, fibres, composites); xxx

2015 IAEA Gen. Conf. Sci. Forum on '**Atoms in Industry: Radiation Technology for Development**'

- Opening Plenary
- **6 Topical Sessions**
- Concluding Panel

IAEA-GC-2015 **Scientific Forum:** Sep 15-16, 2015
https://www.iaea.org/about/policy/gc/gc59/scientific-forum

- Tracing the pathways
- Bolstering safety & quality
- Rays of hope
- **Battling the bugs**
- **Solutions for pollution**
- **Linking the chains**

Show-casing Global Trends

Atoms for Peace and Development

IAEA International Atomic Energy Agency

Attractive option of Radiation Processing (RP) for unique/high value-addition *vis-à-vis* Associated techno-economic aspects

- **sterilisation & hygienisation** of products

- **need**: safety of health care products; prolonged preservation *cum* safety of food items → *cost justification*

- addressing and **treating (harmful) pollutants**

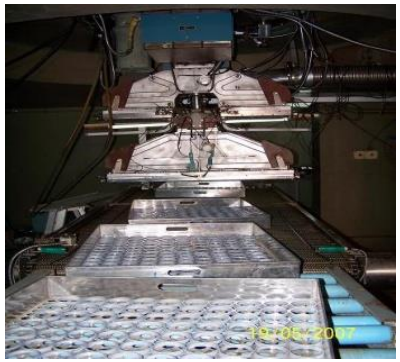
- **reason**: high risk + cost to society and/or environment, by not-treating the pollutants; *putting a cost figure not easy*

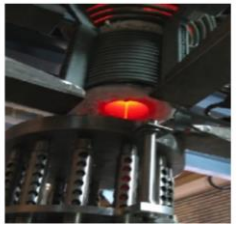
- **material modification** *(polymerization, crosslinking, grafting, controlled degradation)* to avail of unique or desired features

- **high/unique utility** of advanced materials invariably absorbs the cost (kGy to MGy) → *faciltated affordability*

RP Technology Options and Radiation Sources

- Technology: ionizing radiation energy used; no-chemical-addition, room temp process, pre-packaging compatible
- ***2 major options available with known Pros and Cons***
- gamma radiation from sealed radioisotope (RI) sources: mostly ^{60}Co, 100 kCi to 5 MCi
- electron beam (EB) from accelerators: ≤0.3 MeV; 1-3 MeV; 5-10 MeV; and 10s-100s kW power
- Bremmstrahlung X-rays from high energy (5-10 MeV) electrons
- EB unit (low energy) on-line in industry, e.g. sanitising-sterilizing beverage containers
- *Facilities: 300+ RI-based; ~1700 EB units*





Establishing Radiation Processing Facility (RPF)

- Needs and issues to be addressed

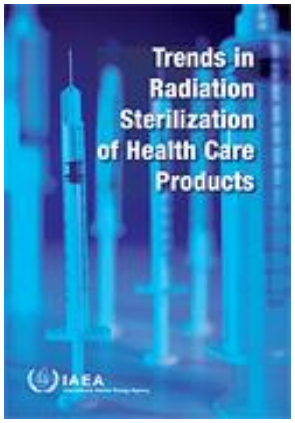
- main drivers for facility; product profile; transport logistics

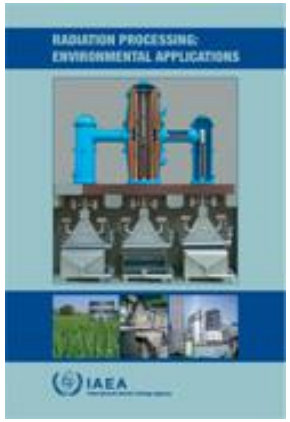
- Technology aspects

- fixed dose (range); known protocols; treatment duration

- mixture of products; varied dose delivery;

- infrastructure support





- Management/Ownership aspects

- dedicated facility v/s service provision to various users

- Private; Public (national labs); PPP model; others

- Nuclear Security concerns vis-à-vis RI sources use?!

  cf. X-1000 MCi-Year services of gamma plants globally!

- Technology neutral approach essential: to ensure industrial interests do NOT air 'anti-tech' views

Radiation Processing Facility (RPF): Management & Ownership Types

- National labs/centres

- e.g. BRIT-India; MNA-Malaysia;

- Industrial ventures

- NIPRO, Pune-India;

- Entrepreneurship efforts to deliver services

- e.g. Organic Green Foods, India; Vina-Gama, Vietnam

- 'Stakeholder' entities operating units

- Microtrol, India; Agro-Surg, India; MSAMB, India

- xxxxxx

Radiation Processing Facility: Cost Elements

- Fixed initial cost

- plant cost (main system, shield-vault, product handling system, etc.); infrastructure; (land cost/levy); statutory deposits; xxx

- Operational cost

- O&M; staff cost; utilities like power supply (approx. 100-140kW for EB plant; 10kW for gamma plant), 'cold-chain' cost, if applicable; security-related; logistics; xxx

- Dose-dependent service cost

- Dose delivery duration; continuous v/s batch process (back-up plant for 'continuous' needs); xxx

- Overheads

- Admn.; Taxes; Insurance; CSR; xxx

- Misc. – Others

Typical Costs *cited by two 'friendly' sources*

- Installation ('X')

  - EB system: low-medium energy: 1.6-2.3M$; high energy 2.5-3.3 M$

  - Co-60 1 MCi plant: 3.3M$; 100MRs (1.6M$)

- Maintenance

  - 2 to 5% of 'X' p.a. for EB plant

  ¬10% of 'X' p.a. for Co-60 plant (with source replenishment cost component)

Sources acknowledged: Dr BS Han, ROK; BRIT-India

Radiation Processing: some cost aspects *(1 of 2)*

- Cost of delivery of radiation dose to product is almost always independent of the cost (value) of the product!
- Different commodities require different doses of radiation
- Needs for continuous radiation treatment warrant back-up plant(s)

- **The higher the value of product to be treated, and the lower the radiation dose to be delivered, the better would be in general the economic viability.**

- Lower radiation dose delivery requirement is not necessarily adequate for reducing cost of radiation treatment

X cent per kg (base cost) **+** X' cent per kg per kGy (dose dependent cost) → total cost of RP service

→ cost per kg per total dose of radiation required = x% of value of material (e.g. certain food & agro commodities); *say x ≤5*

Radiation Processing: some cost aspects *(2 of 2)*

Food and Agro products have other issues to be addressed

- seasonal availability of produce; region-wise products
- dose required varies by orders of magnitude e.g. 30-50 Gy for onions/potatoes; >10 kGy for spices
- transporting products over long distances not practicable for logistics and cost reasons
- *'cold-chain' statutory needs to be complied with (+ costs)*
- *National legislation status and public acceptance aspects in some regions/countries* (*not discussed much in this presentation*)

Material modification: variable dose, incl. some very high dose needs → 'processing chain to end-products' → several factors impact final product cost, and RPF fee seldom a burden.

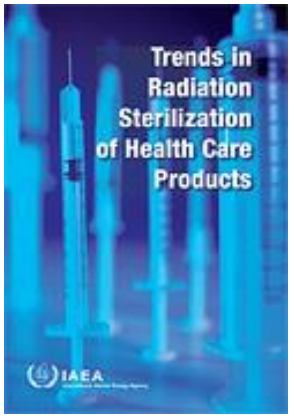
Radiation Processing Service Charges (+): India/DAE model based on 'differential fees'

- Medical products/devices

- High value items of large volume e.g. *sutures* **++++**

- High value items of smaller volume **++(+)**

- Low cost items e.g. *surgical cotton* **+**



- Spices & Allied Products

- High value items of large volume e.g. *pepper* **+++**

- High value items of smaller volume **++(+)**

- Low cost items e.g. *dried onion powder* **+**

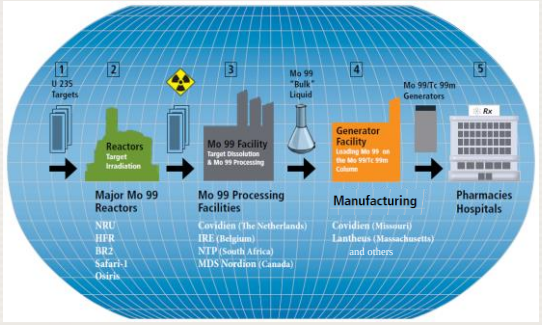
- Fruits, other Agro Products

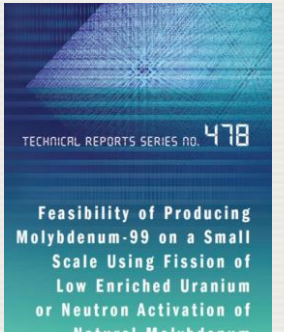
- 'Administered fee' based on typical cost range, or declared cost, of the commodity

2008-10 ^{99}Mo crisis eye-opener! NEA Report on economic aspects of ^{99}Mo supply chain

historical market development sans economic case

- reactor irradiation prices set too low to support infrastructure development
- commercialisation reinforced low prices & created market power
- building additional capacity can increase supply, but not an economic panacea
- calculations confirm: economic structure inadequate; ^{99}Mo industry unsustainable
- Government support sustained ^{99}Mo industry; need to re-examine level of subsidies





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caveat for RPT: not to fall prey to similar issues; need economic viability

Factors driving (developing) MS interest in Radiation Processing Applications

- high safety of medical products sterilisation
- ability to produce (advanced) materials of superior features
- scope for (high) value addition by modification of (low cost) materials to suit specific purposes and applications
- enhancing food safety, quality, and trade prospects - sanitary, phytosanitary role
- need to ensure improved industrial practices and address increasing environmental concerns - meet (mandatory) limits on pollutants in waste stream
- sheer versatility of radiation processing → contribute to advances in other fields, e.g. nanotechnology; medicine

IAEA @ 60 year milestone in 2017 Atoms for Peace and Development

- IAEA global reference centre for MS for objective, authentic guidance on all nuclear-related matters →
- guidance on scope + cost of technologies to facilitate sustainable harnessing of applications
- providing holistic advisory assistance & technology-neutral approach based on appropriate criteria for radiation processing
- Imperative to send signals in unison to national policy planners & resource providers - open to scrutiny by stakeholders + be unequivocal

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60 Years
IAEA Atoms for Peace and Development

Ideally desirable information for MS regarding Radiation Processing Plant/Facility

- Typical facility establishment cost, for both gamma plant and EB plant (for a few typical configuration)
- Operational cost per annum for both types of RP plants + respective infrastructure & other resources needed
- Typical capacity utilisation factor target - keeping product profile, O&M needs, etc.
- Radiation treatment service cost: x-y cents per kg (or ton) of product - for delivering the required specified radiation dose

  suggestions: (i) Topic for coverage in IAEA's NTR-2017, as a thematic supplement; (ii) IAEA Publication: 'Milestones document for establishing RP Plant'

Quotes as summing up message

'A life of joy and happiness is possible only on the basis of knowledge and science.'
Dr. Sarvepalli Radhakrishnan
2nd President of India; renowned philosopher & luminary par excellence

'Every profession bears the responsibility to understand the circumstances that enable its existence.' *Mr. Robert Gutman*
(continuous evolution, viability, sun-set clause)

'Nuclear techniques are used extensively in industry to increase product quality & safety, benefiting both producers and consumers; radiation tools make industrial production cleaner and more effective'. *Mr. Y. Amano, DG-IAEA*

Acknowledgements

IAEA; BARC + BRIT + DAE; Colleagues & Collaborators of past & present

Thank you all for attention!

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