The Role of Engineering to Address Climate Change

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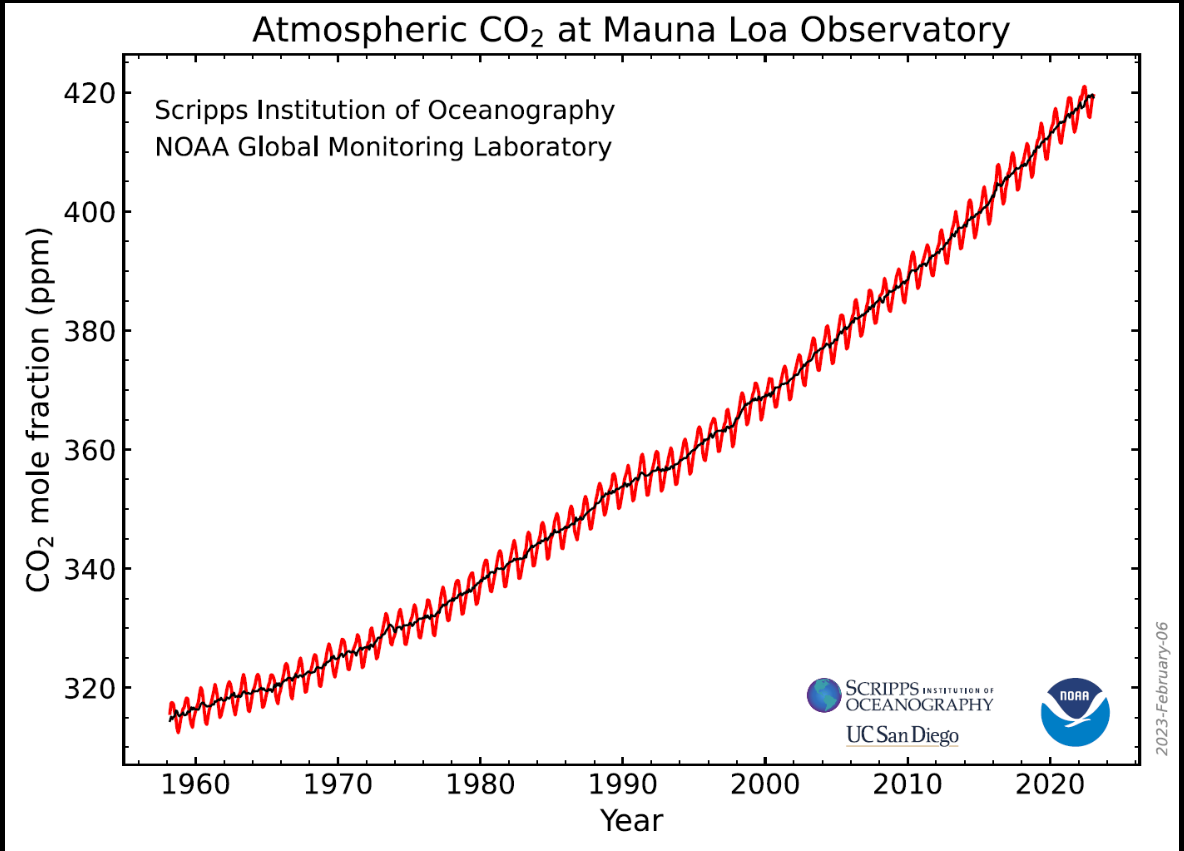
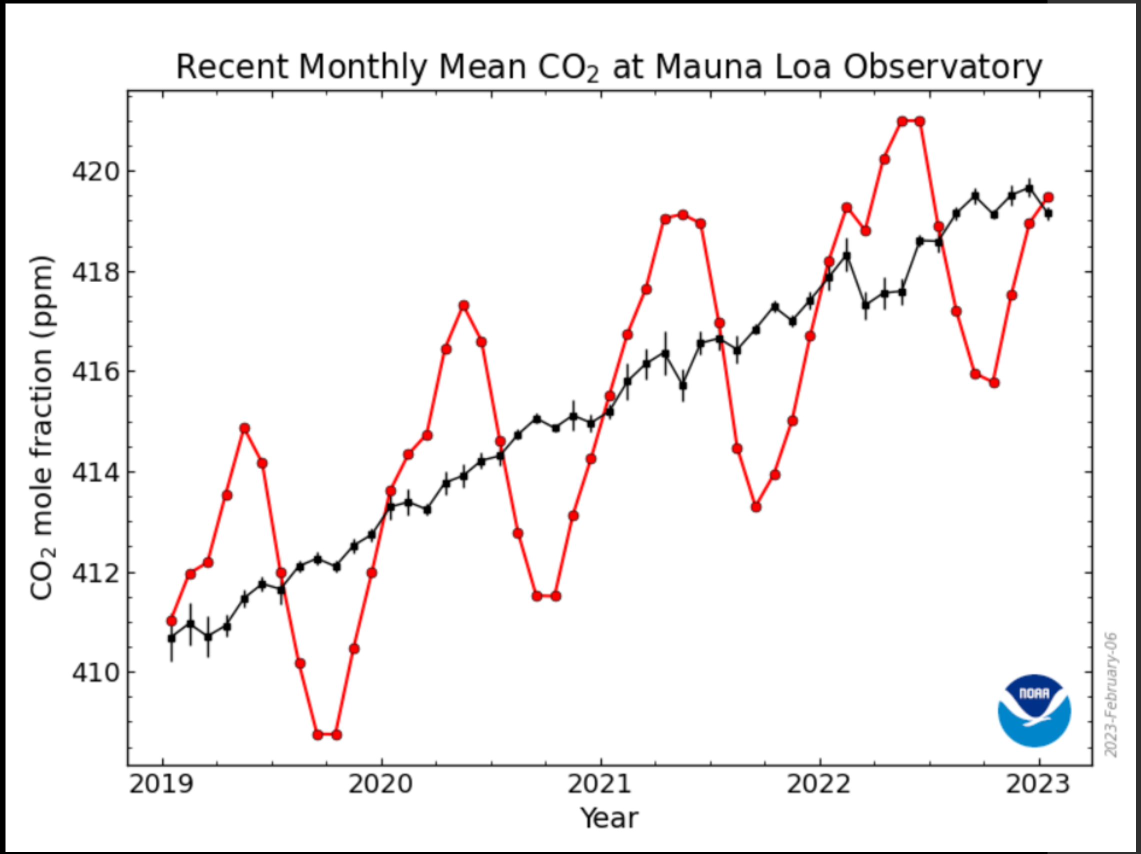
Climate change threatens our society

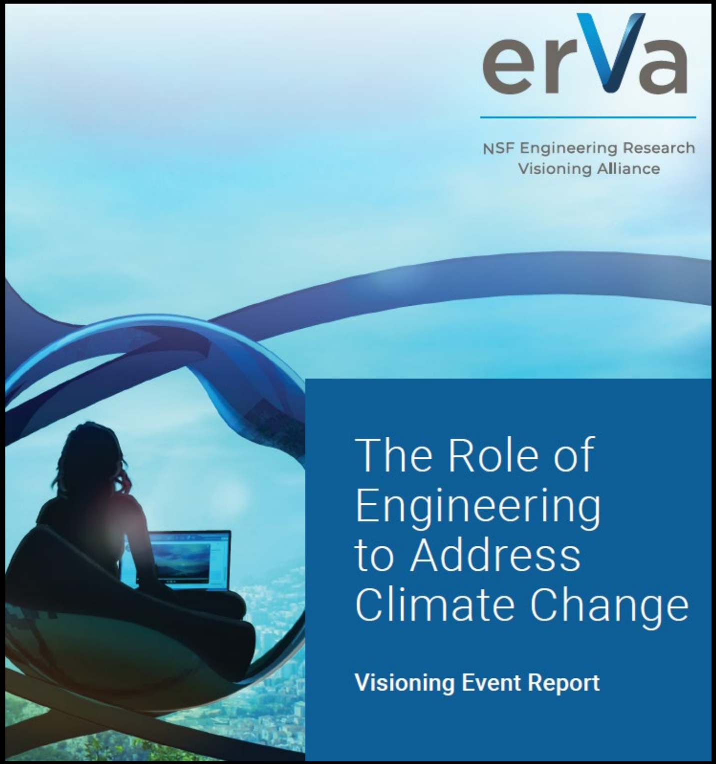
Engineering solutions are needed

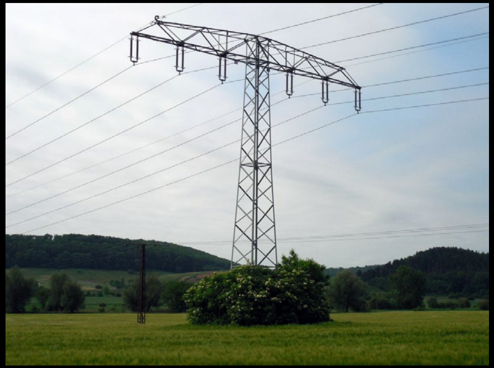




Red lines = monthly mean values
Black lines = monthly mean values, corrected for avg. seasonal cycle

Engineering solutions are needed



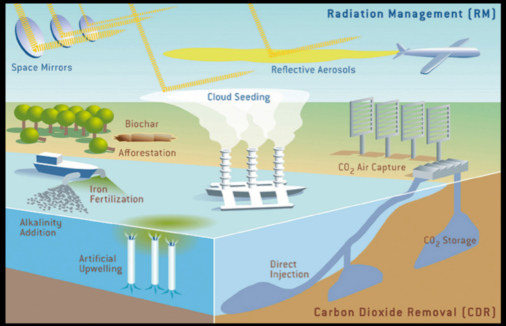


Energy storage, transmission, and critical materials

GHG capture and elimination

Engineering within inclusive and equitable societies

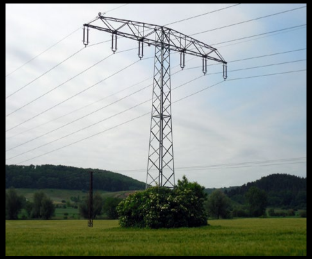
Resilient, energy-efficient, and healthful infrastructure



Water, ecosystems, and geoengineering assessment

Role of nanotechnology and material science

Critical materials



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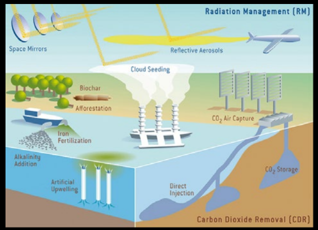


Water, ecosystems, and geoengineering assessment

"Critical materials in all engineered systems, especially in extraction, separation, recycling and upcycling, and energy conversion, as well as carbon dioxide (CO2) mitigation."

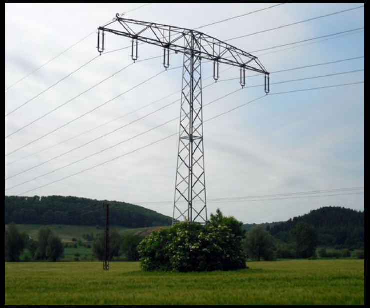
ERVA report

Nanoengineered materials

ENERGY STORAGE, TRANSMISSION, AND CRITICAL MATERIALS

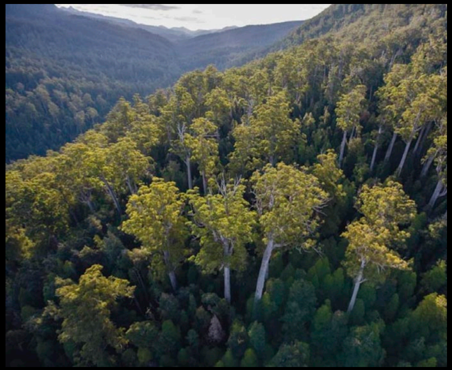
- Nanoengineered materials for critical mineral separation, extraction, and recycling;
- Chemicals or materials for non-traditional energy storage such as reversible electron shuttles in flow batteries and hydrogen gas;
- Materials for extracting additional energy from heat cycles by harvesting low-grade heat in new ways, such as thermal flow batteries and thermoelectrics; and
- Developing new ion exchange membranes to replace fluorinated membranes used in critical electrification systems, such as fuel cells, water electrolyzers, and other separation systems, with non-PFAS (per- and polyfluoroalkyl substances)-based membranes and with sufficient durability to withstand harsh conditions.

Role of critical materials



Energy storage, transmission, and critical materials

- Basic materials and separation
- New materials to engineer better batteries
- Improve mining and production of minerals used in batteries



GHG capture and elimination

GHG capture
- Improve materials for solvent and sorbents for CO2
- Improve materials for energy conversion and CO2 mitigation
- Conversion of CO2 into materials that will not contribute to atmospheric CO2

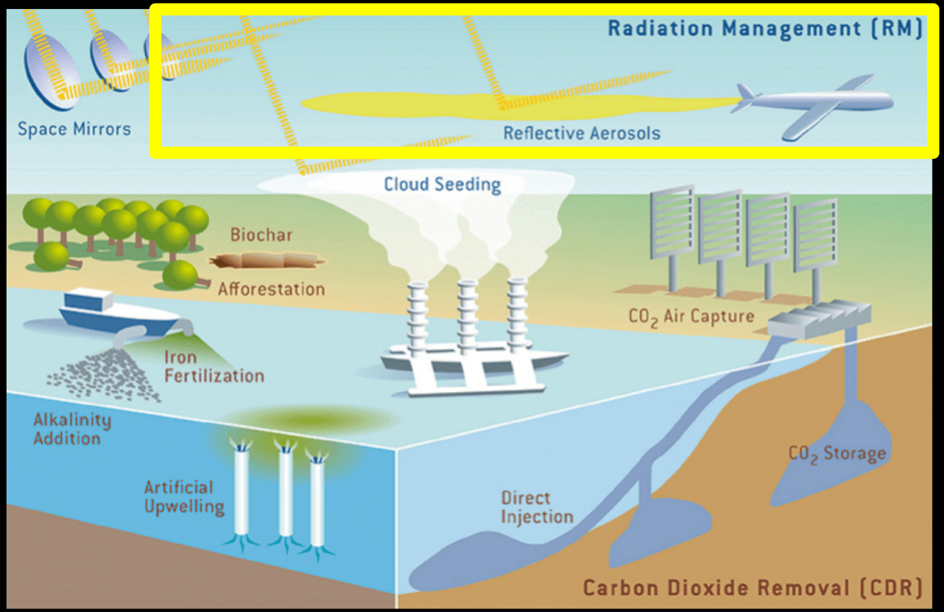
Decarbonizing industrial processes
- Better understand thermal conduction in insulating materials
- Material alternatives that are carbon-neutral

Role of critical materials

Resilient, energy-efficient, and healthful infrastructure

Infrastructure, buildings, transportation
- Better understand future life of materials in infrastructure
- Bio-based, bioengineered solutions

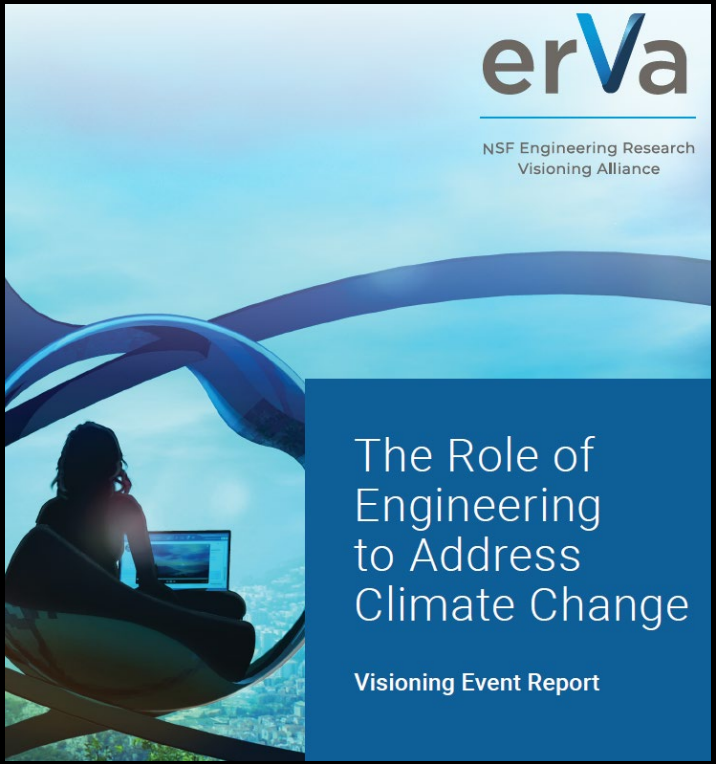
Solar and renewable energy
- Engineer passive cooling materials
- Improve lithium and materials recovery and reuse from brines (geothermal energy)

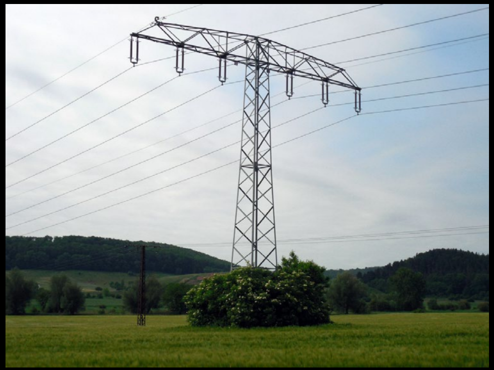


Water, ecosystems, and geoengineering assessment

- Not mentioned explicitly
- Could play a role in solar geoengineering

Inclusion and equity in engineering solutions





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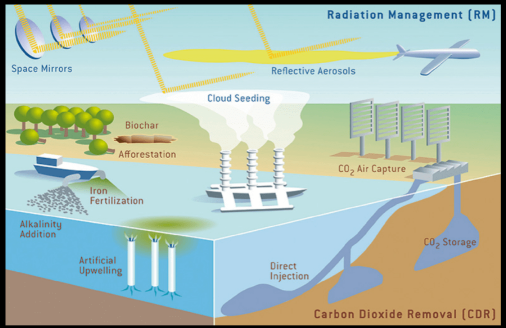
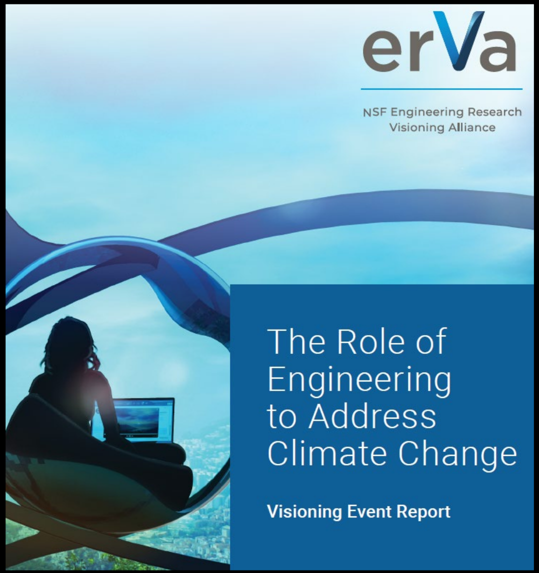


Water, ecosystems, and geoengineering assessment

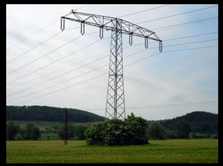
Inclusion and equity in engineering solutions

1. Affordable access to renewable energy
2. Enhancing multi-use land applications for solar, wind
3. Create, leverage multinational programs of scale that weigh technical and social benefits
4. Improve communication around energy use and emissions
5. Improve link between energy use and reduced carbon emissions
6. Incentive transition to energy conservation, efficiency, renewable energy

Moving forward



- Engineering research priorities to address climate change
- Inspire researchers and funders to pursue these priorities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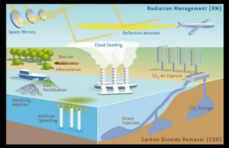

Water, ecosystems, and geoengineering assessment

- Need for stakeholder and community engagement
- Benefits
  - Allow for diverse perspectives
  - Increases acceptance and adoption
  - Creates more inclusive, just, fair, and equitable solutions

Moving forward with stakeholder engagement

- Researchers and innovators need guidance
- Engagement is not an ‘add-on’ but integrated from the start
- Basic steps include:
  - Defining goals
  - Defining and identifying stakeholders and community members
  - Identifying engagement activities
  - Conducting engagement and developing outcomes
  - Learning and revisions

Moving forward with stakeholder engagement

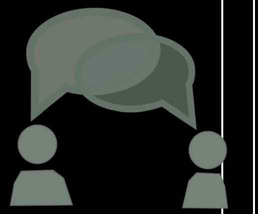
Goals

- Consultation: Understand views, perceptions, needs, concerns
- Communication: Outreach and education
- Collaboration: Co-create solutions together

Identifying stakeholders

- Individuals, groups who have a stake
- Diverse sectors
- Diverse perspectives, viewpoints, needs
- Knowledge, insights, experiences
- Selection via e.g. location, interests, influence, social networks, etc.

Activities



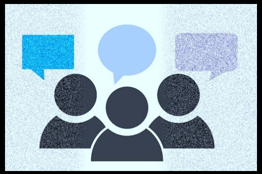
- Consultation: Surveys, interviews, focus groups
- Outreach and education: Science exhibits, media, etc.
- Collaboration: working groups, advisory boards

Conduct, review, and revise

- Conduct engagement
- Compile and formulate outcomes
- Reflect on lessons learned
- Revise in subsequent steps

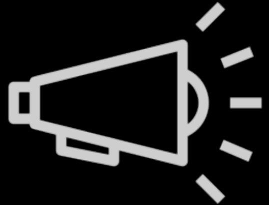
Grieger et al., 2022

Moving forward with stakeholder engagement



Public perceptions of nanotechnology

- Overall awareness has been low
- Attitudes are application-dependent
- More support for products:
  - Benefit > Risk ratios
  - Less direct exposure to nanomaterials (e.g. electronics) compared to direct exposures (e.g. food)
  - Address a societal need
- Less concern about nanotech compared to:
  - Plastic pollution, climate change, pesticides, GMOs
- More trust in scientists and researchers compared to industry and government officials



Communication strategies

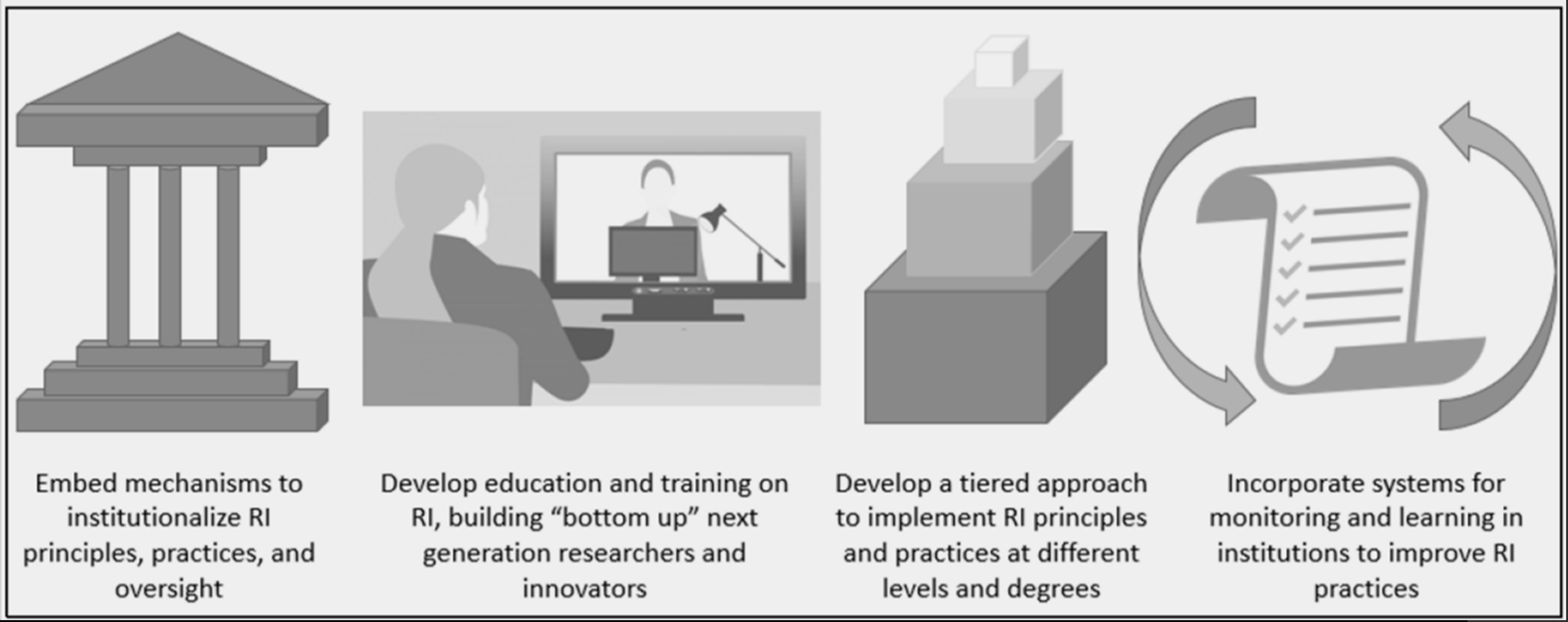
- Education and outreach for raising awareness
  - Tailored for specific audiences
  - Use various media
- Clear communication about benefits
- Communication on safety and environmental impacts
  - Improve knowledge of risks over life cycle
  - During manufacturing
  - Use (if applicable)
  - End of life

Grieger et al., 2021, ECHA 2020, Boholm and Larsson 2019

Moving forward with responsible innovation

- Process to anticipate risks, include diverse perspectives, and align R&I with societal values, needs, and expectations.
  - Anticipation
  - Inclusion
  - Reflexivity
  - Responsiveness

Responsible Innovation (RI)

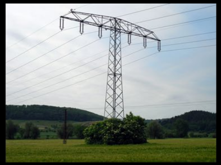


Best Practices for nano-RI

Grieger et al., 2022

Main Messages

- Nanotechnology and critical materials have great potential to address climate change
- To ensure inclusion and equity, researchers need more guidance and priority-setting for engagement
- Communication is key to effective engagement
- Responsible innovation may help in framing of research and innovation for equitable and inclusive solutions



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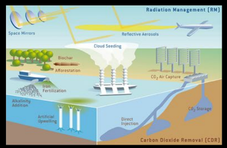

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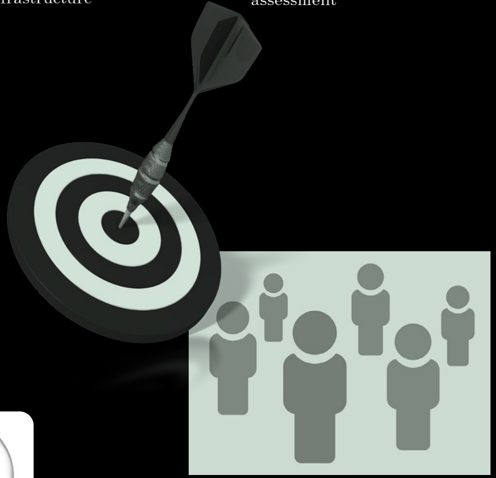

Thank you

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