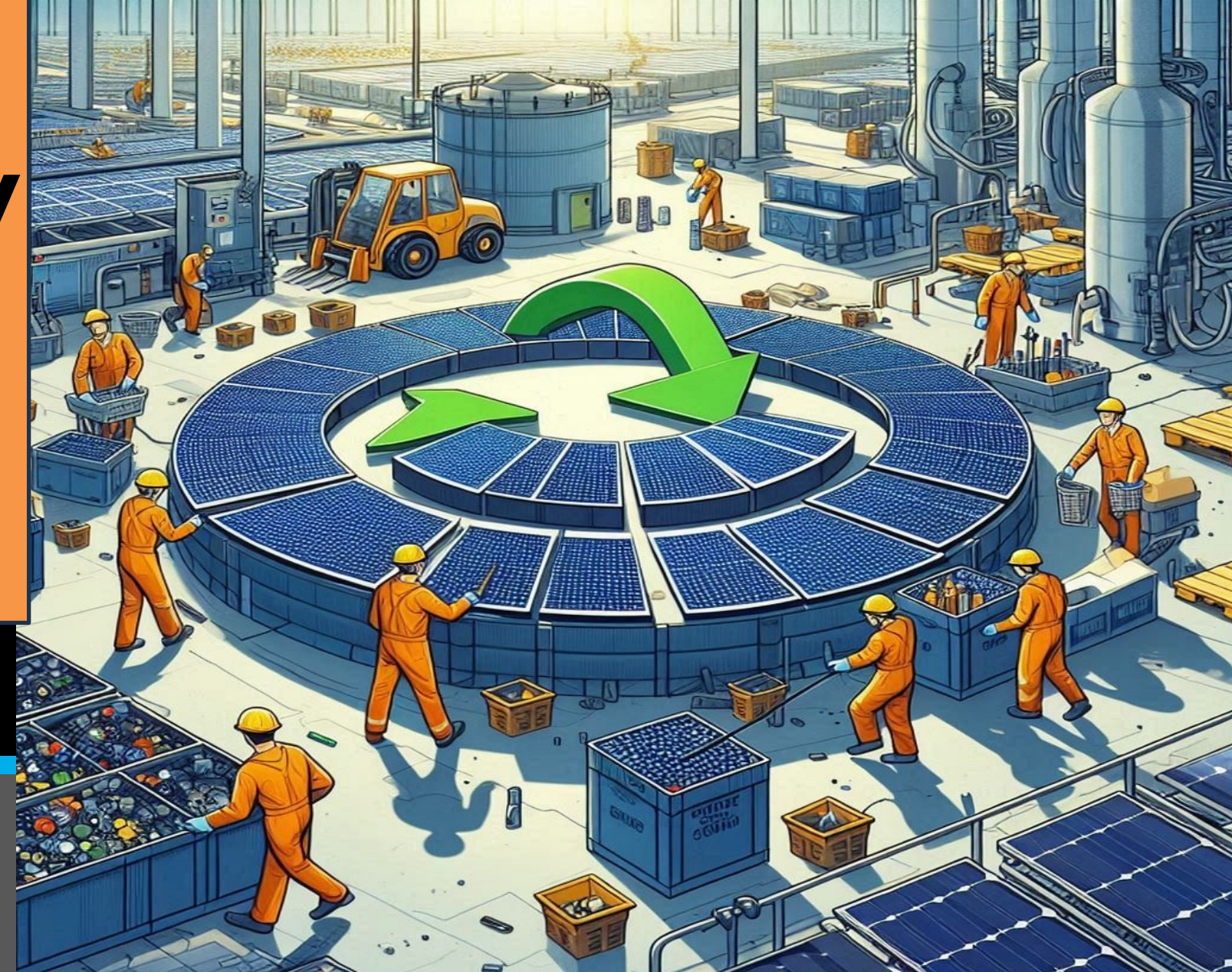


# Advancing Circular Economy Principles in the Solar Industry

## Focusing on the Canadian market



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### Abstract

This project explores challenges and opportunities for integrating circular economy principles within the Canadian solar industry. The research assesses the environmental, social, and economic benefits of advancing circular economy principles through literature reviews and interviews with industry professionals. Also, examining the regulatory landscape and the role of technological advancements in promoting sustainable practices. Findings highlight the growing concern over solar panel waste and the need for effective waste management strategies to mitigate environmental hazards. Recommendations include developing robust recycling services with support and partnership from the Canadian Association of Recycling Industries to manage the expected end-of-life waste. Establishing a reused panels market and advancing sustainable and recyclable solar panel technologies will be critical to a circular economy. Overall, this research seeks to contribute to the existing body of knowledge by providing actionable insights for industry stakeholders, policymakers, and investors, aiming to foster a circular solar industry.

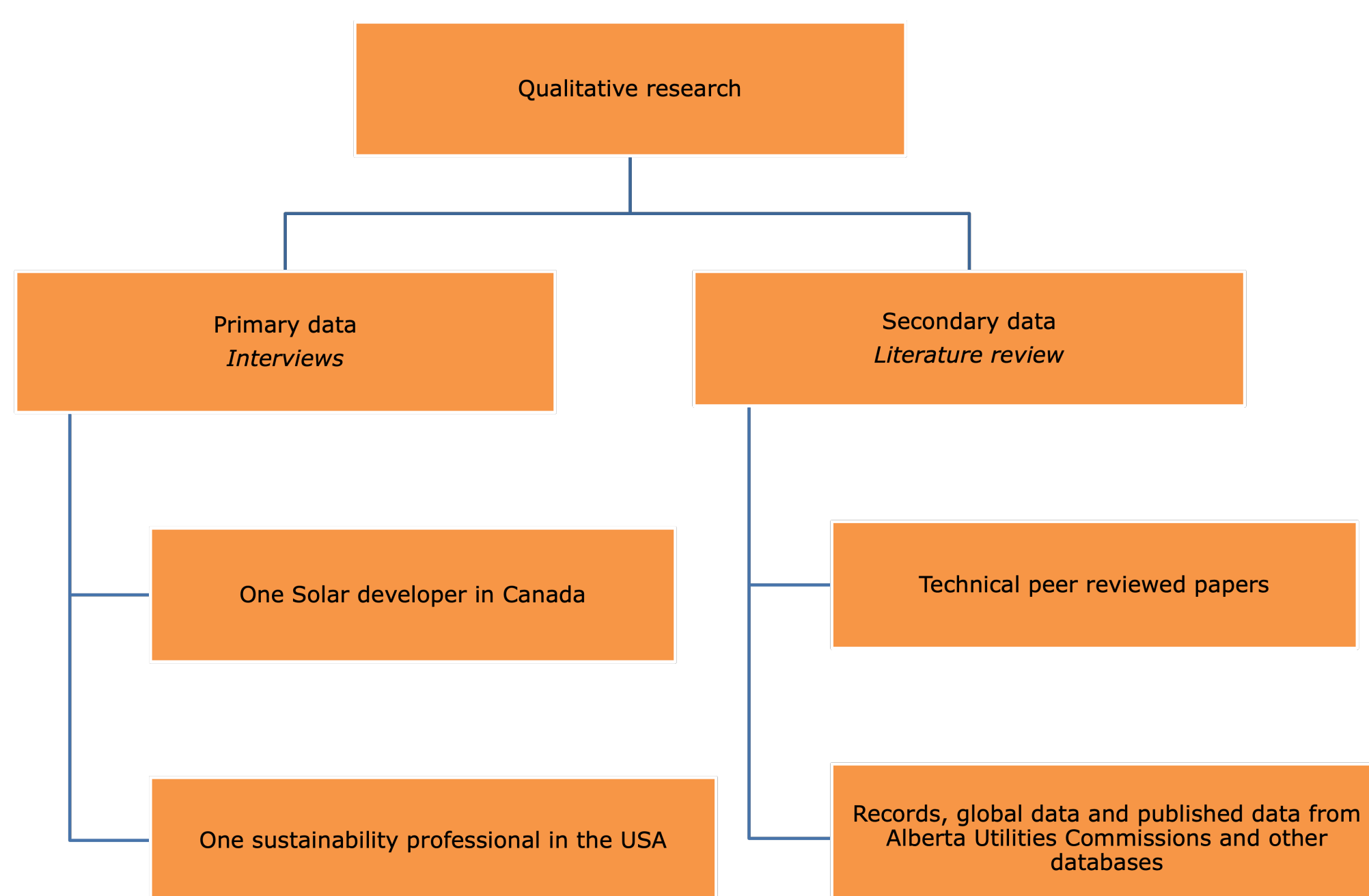
### Research Question

How can environmentally conscious investors or developers integrate circular economy principles into the management of end-of-life solar photovoltaic (PV) panels during the conception and execution of future solar projects?

### Introduction

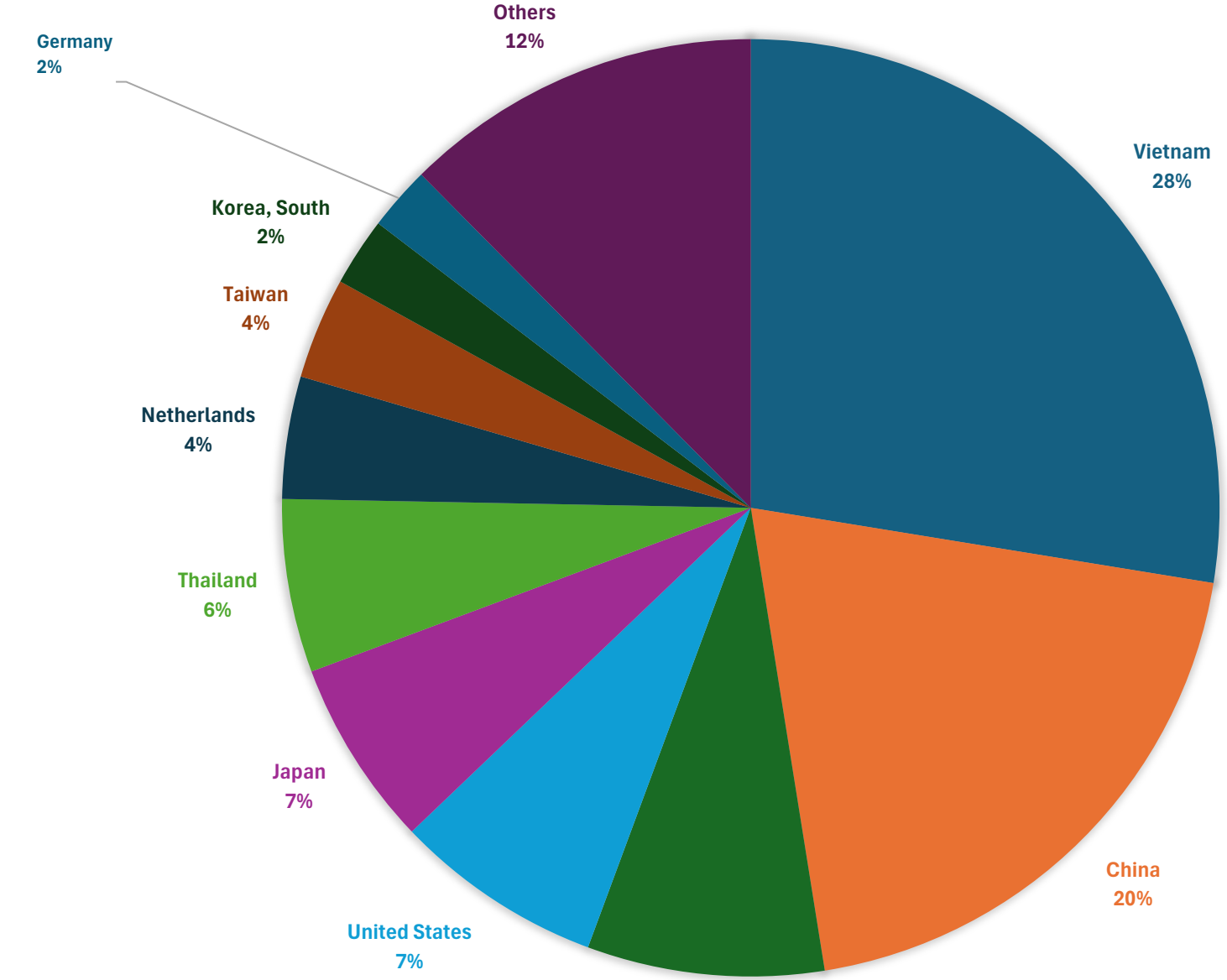
- The evolution of energy sources has been a complex and ongoing process shaped by various factors, including technology, economics, and environmental concerns. (Fouquet & Pearson, 2012).
- Renewable energy sources like solar and wind have the potential to be more sustainable and less damaging to the environment than traditional sources like coal and oil; they are not without their environmental impacts
- Projections show that by 2028, solar will double from the levels recorded in 2022, resulting in approximately 710 GW of renewable energy capacity (IEA, 2023a)
- Therefore, it is imperative to consider the environmental impact of renewable energy sources as we shift towards them as a response to climate change (Solomon & Krishna, 2011).
- Circular economy concept aims to minimize resource input, waste, and emissions by promoting materials' continual use and regeneration (Geissdoerfer et al., 2017).
- Advancing circular economy in the solar industry involves changing design manufacturing to improve end-of-life practices and management components and effective recycling technologies that can extend product life and reduce the industry's reliance on new resources (Shi & Yit, 2012).
- This project is a comprehensive interdisciplinary initiative that spans the domains of energy, environment, and economics. It focuses on two Sustainable Development Goals (SDGs): SDG 7 and SDG 12.

### Methodology



### Findings

#### Design/Manufacturing



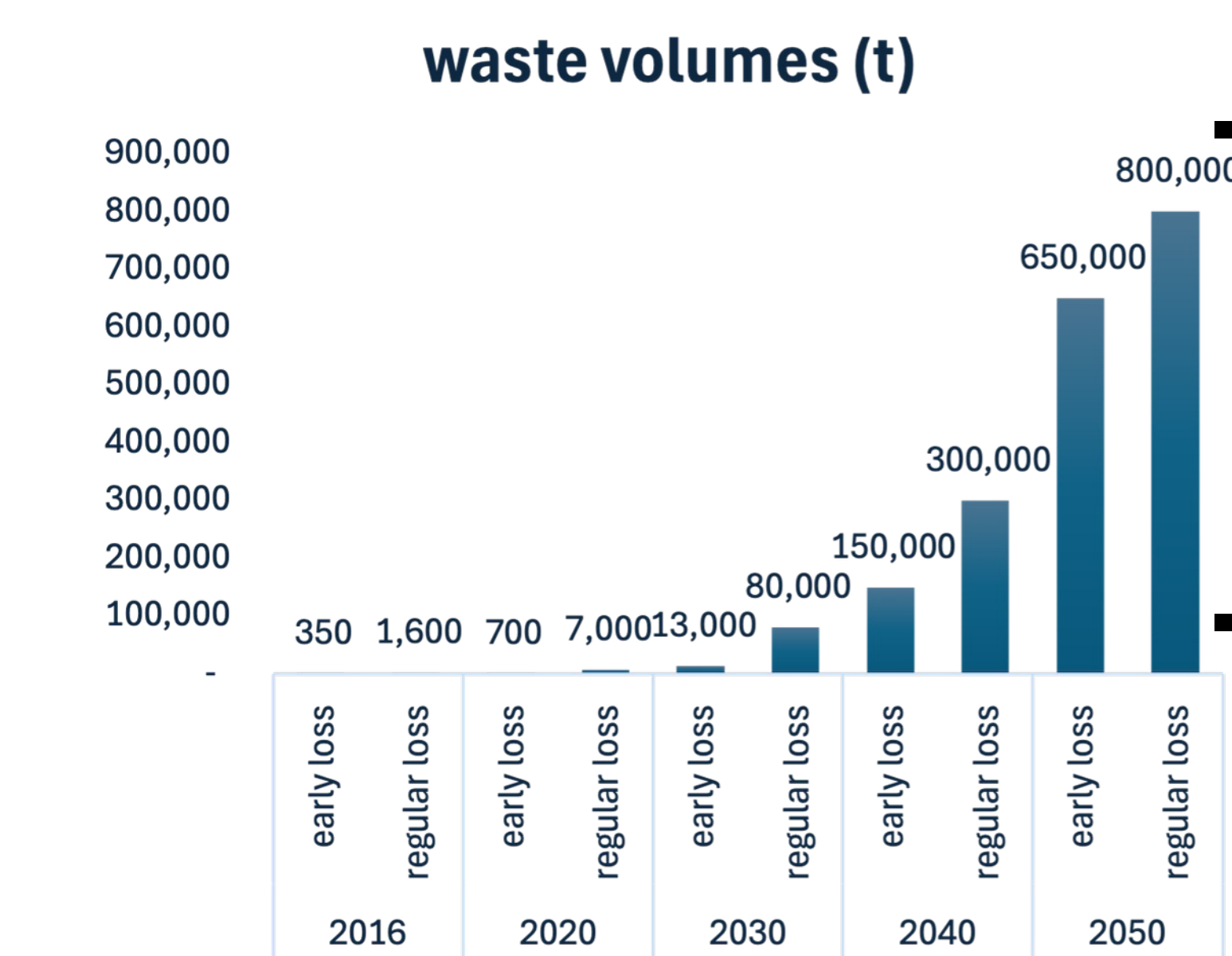
Source of Canada's Solar Panel products (Government of Canada, 2022)

#### Distribution/Installation & Maintenance

- Canada is largely dependent on imported solar PV
- In 2024, about 5 Manufacturing facilities exist in Canada
- ~ hundreds of solar PVs get damaged during maintenance
- Management of damaged PVs are typically built as part of the contract clause

Solar developer, personal communication, June 20, 2024)

#### End of Life and Decommissioning

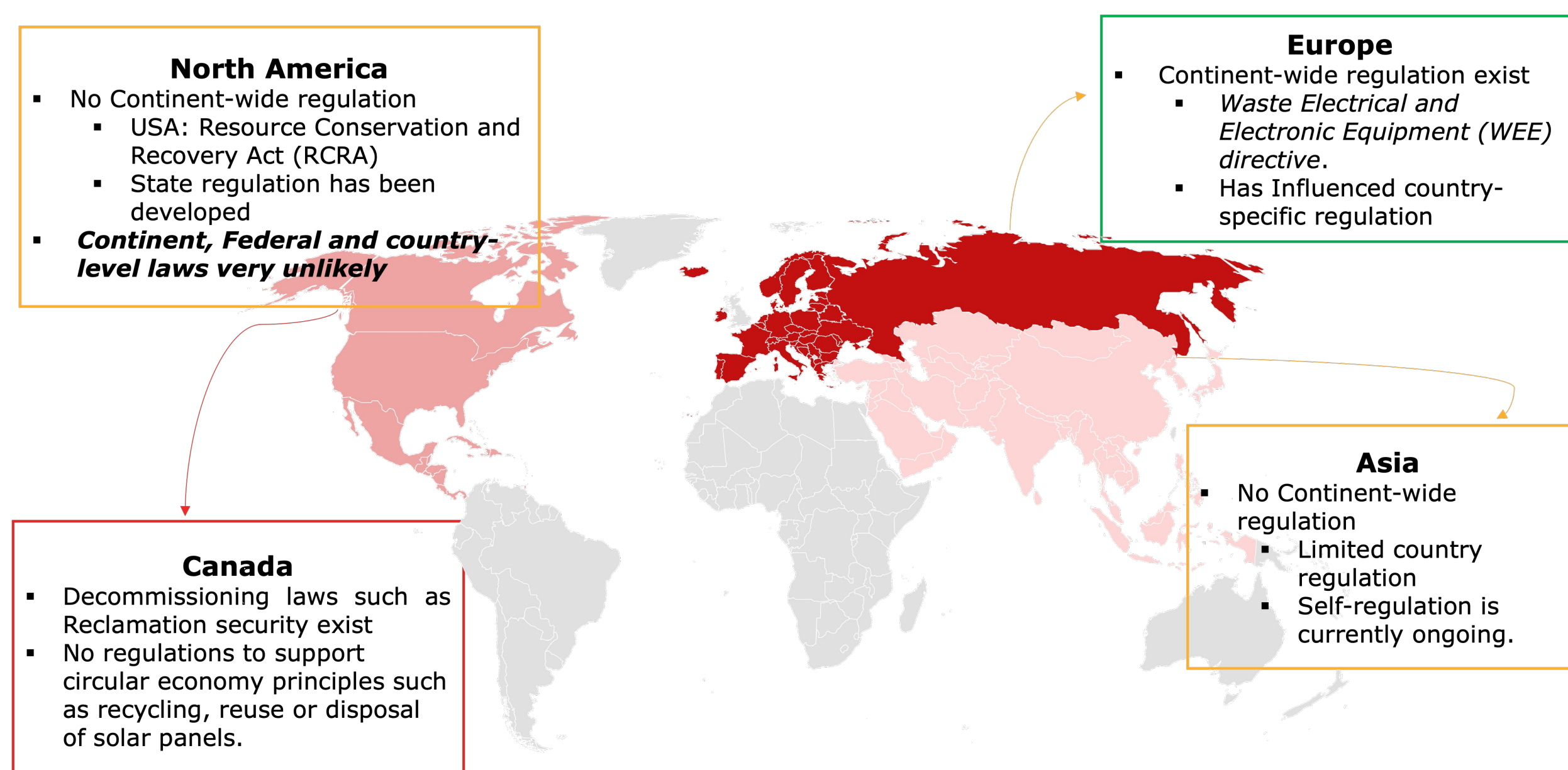


Canada's Estimated Waste Volumes of PV Panels (IRENA, 2016)

Globally, solar PV waste is projected to surge from 0.2 million tonnes in 2021 to over 200 million tonnes by 2050.

In Canada an over 500-time increase in estimated PV waste generated

#### End-of-life regulation and legislative

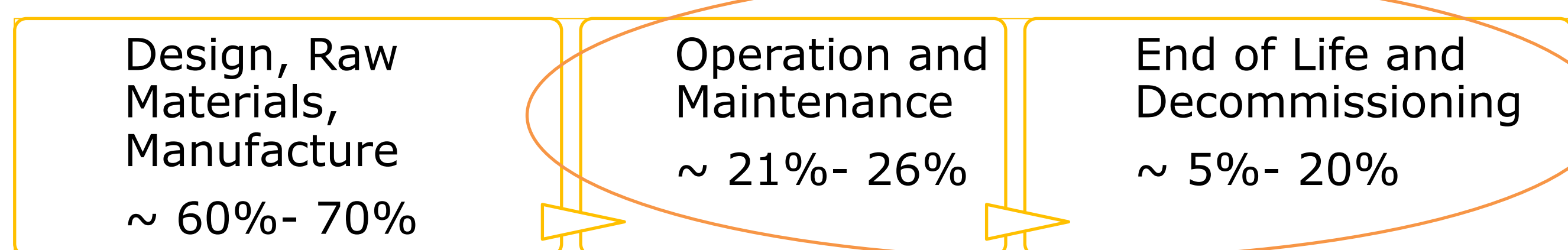


### Analysis

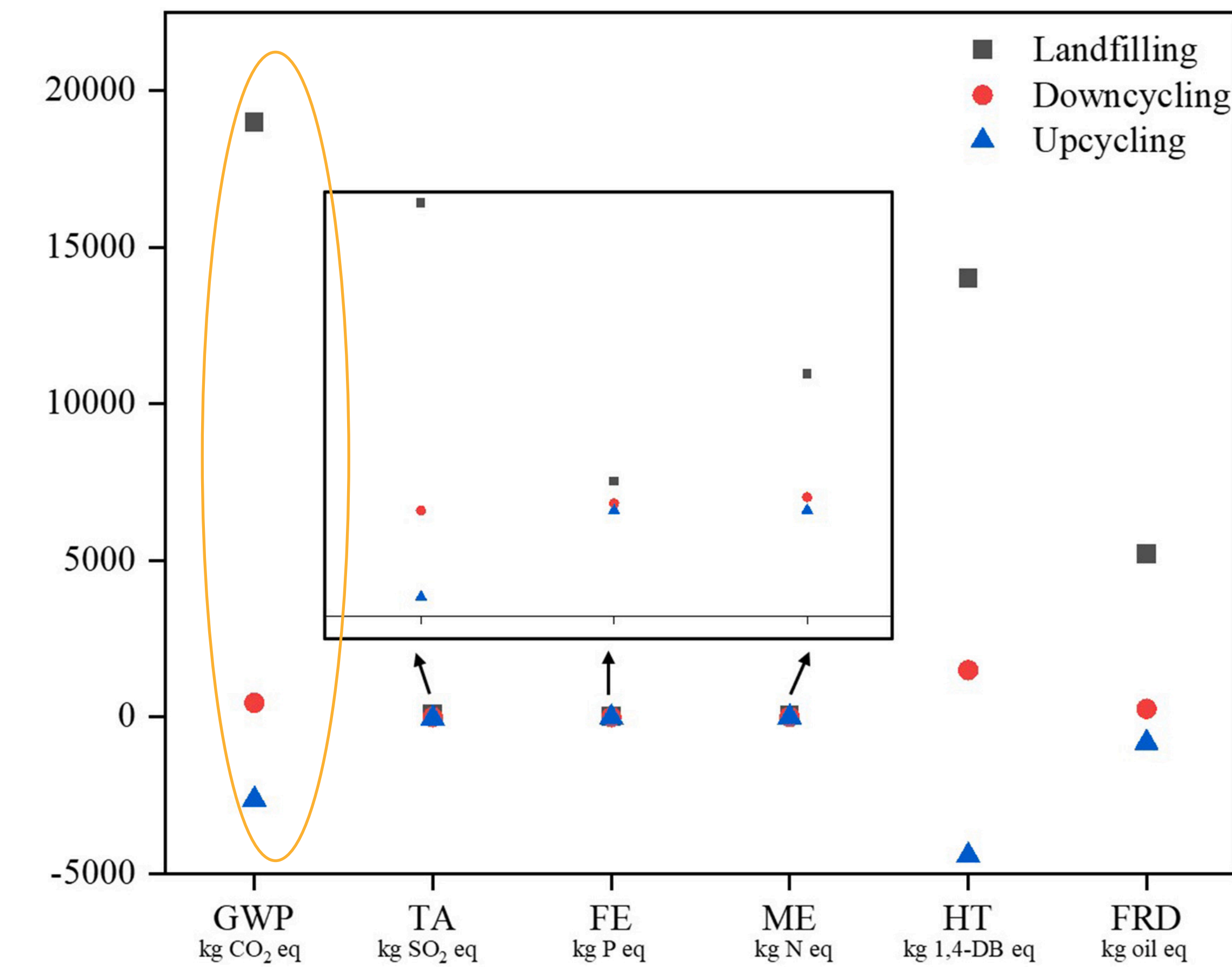
#### Applicability of the 10Rs

Solar Industry Sector	Circular Economy Principles	Applicability in Canada	Rationale
Design	Rethink	✓	Influenced by developers and new/existing regulation
Raw material and manufacturing	Reduce	✗	Panels are imported as a finished product
Technical specification	Refuse	✗	Limited flexibility based on available technology
Distribution, Installation and Maintenance	Repair	✓	Influenced by developers and new/existing regulation
	Reuse	✓	
	Refurbish	✓	
	Repurpose	✓	
End of Life and Decommissioning	Recover	✓	Influenced by developers and new/existing regulation
	Recycle	✓	
	Remanufacture	✗	

### End-of-life Environmental Review (GHG Emission)



Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics (NREL, 2012)



The landfilling, downcycling, and upcycling environmental benefits. (Mao et al., 2023)

### End-of-life Economic Review

#### Current practice

- Landfill cost
- No Revenue
- Potential Negative reputational cost

#### Circular economy

- recycling, refurbishing or remanufacturing cost
- Revenue from the raw material of recovery.
- ~ by 2050 \$15 billion = 2 billion new panels**
- New industries and employment
- Positive reputational cost

(US EPA, 2021a)

### Recommendation and Conclusion

Regulatory and Legislative Intervention

Assessment of the role of The Canadian Association of Recycling Industries as an instrument for deploying recycling in the solar industry.

R & D on development of easily recyclable solar panels or organic solar cells (OSCs)

Development of a potential and robust second-hand market for reuse

- Circularity is critical in ensuring the sustainability of the solar industry.

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