Construction Assessment Framework of Electrical Transmission Structures from Decommissioned Wind Turbine Blades

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BLADE REPURPOSING SOLUTIONS
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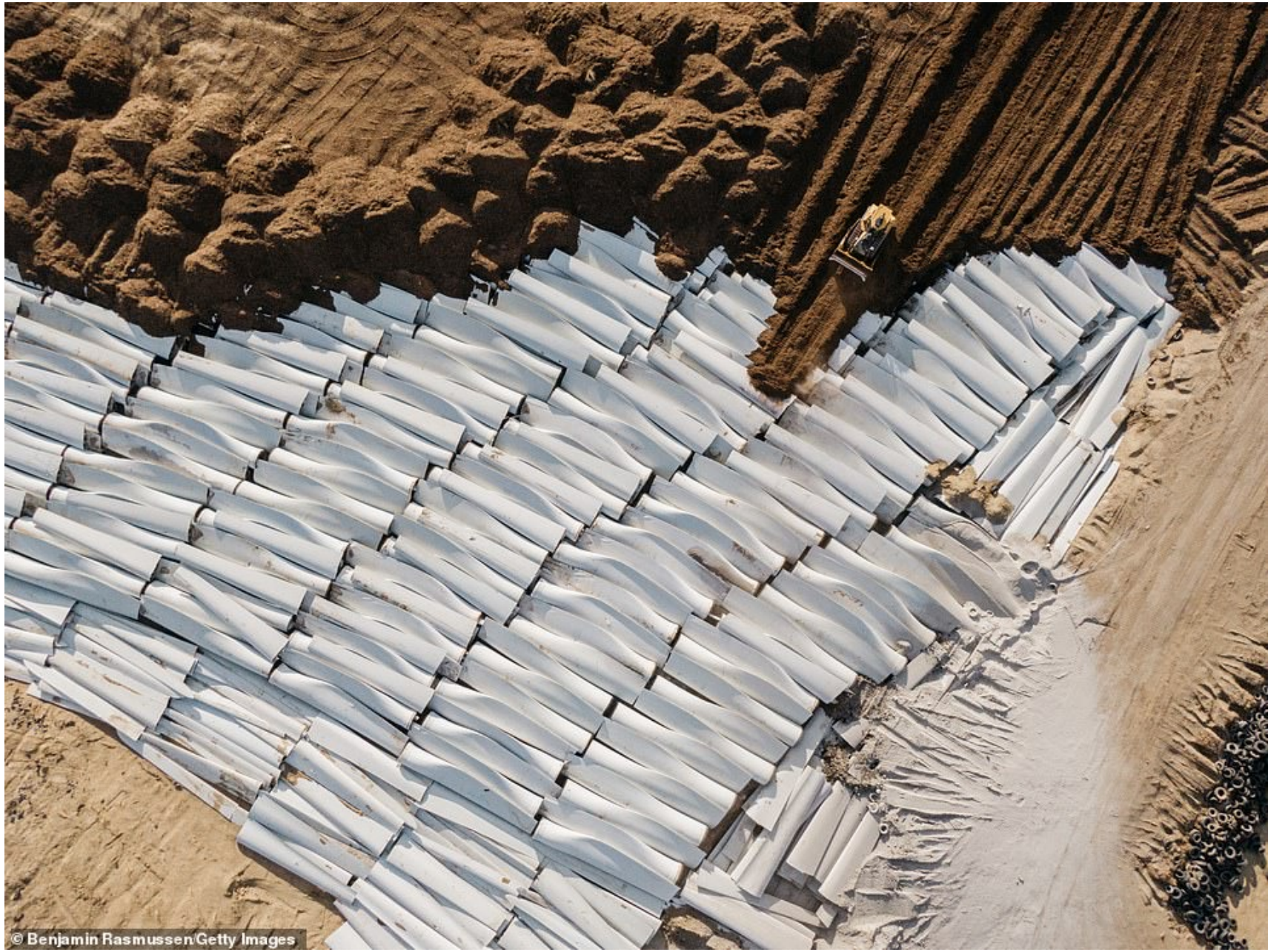
Outline

- Motivation and Impact
- Literature Review
- Methodology
  - Case study
  - Material Flow Analysis
  - Process data flow and exchanges
- Conclusions

Motivation:

Around 8,000 wind turbine blades will need to be removed and disposed of every year in the United States alone.

We look to repurpose these in civil infrastructure.



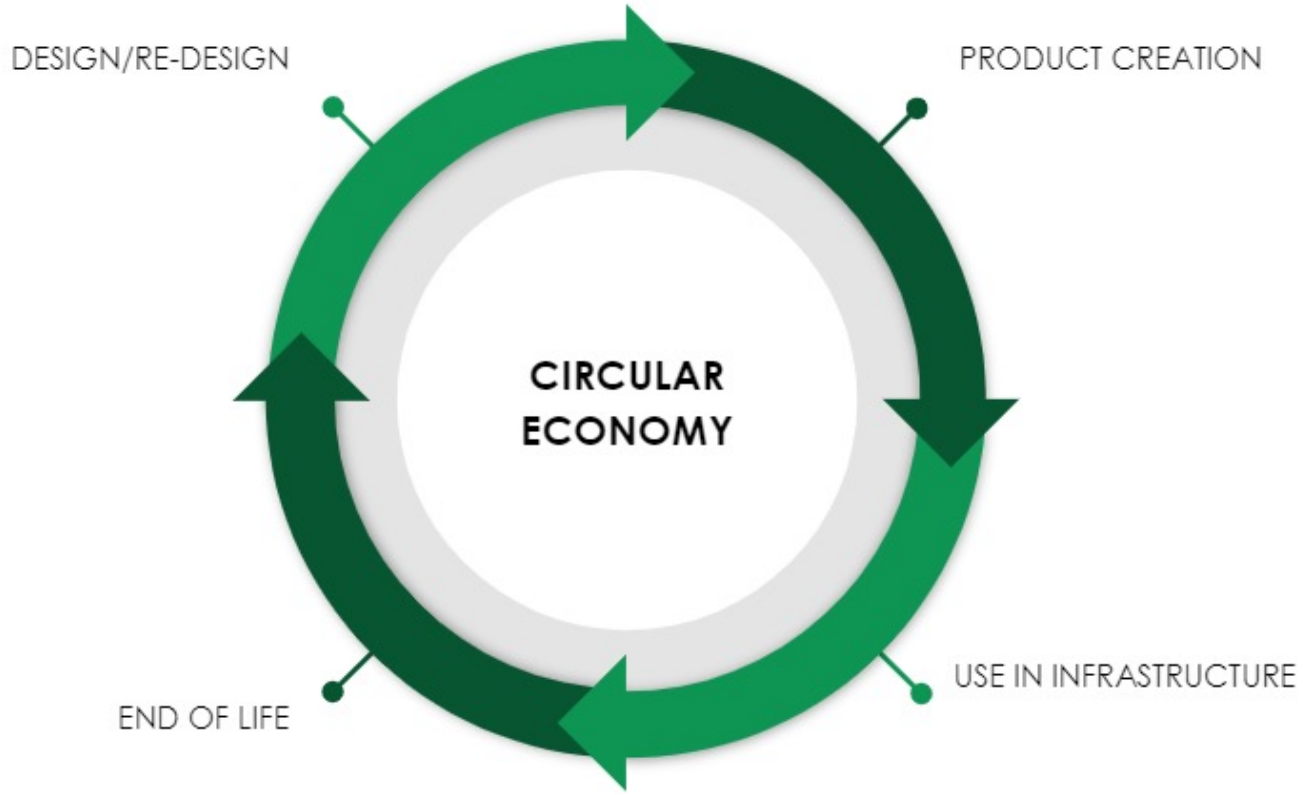
Wind Blades in Landfill (Bloomberg, 2020)

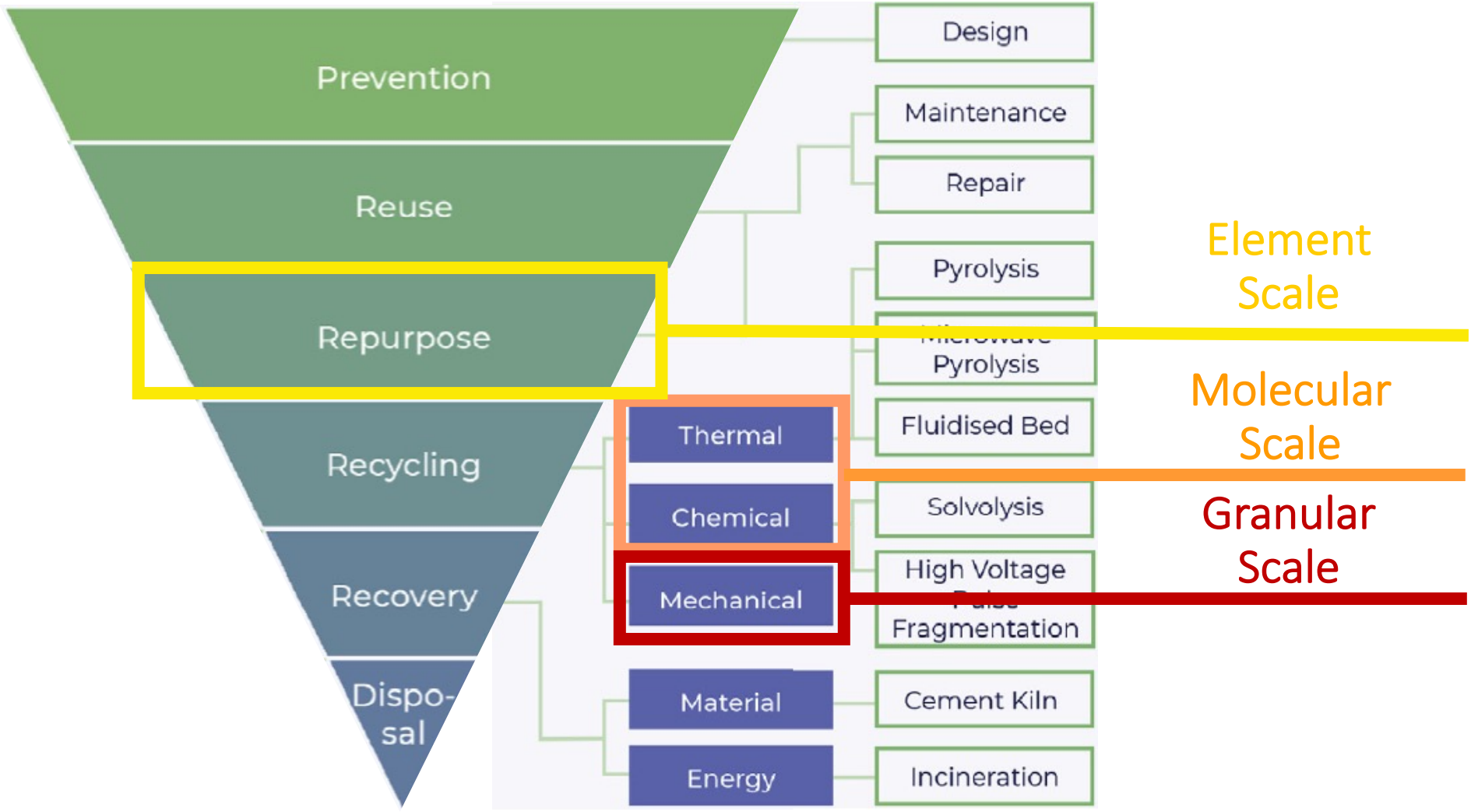
Linear Economy:

Incineration vs. Landfills
(urbanmining, 2020)

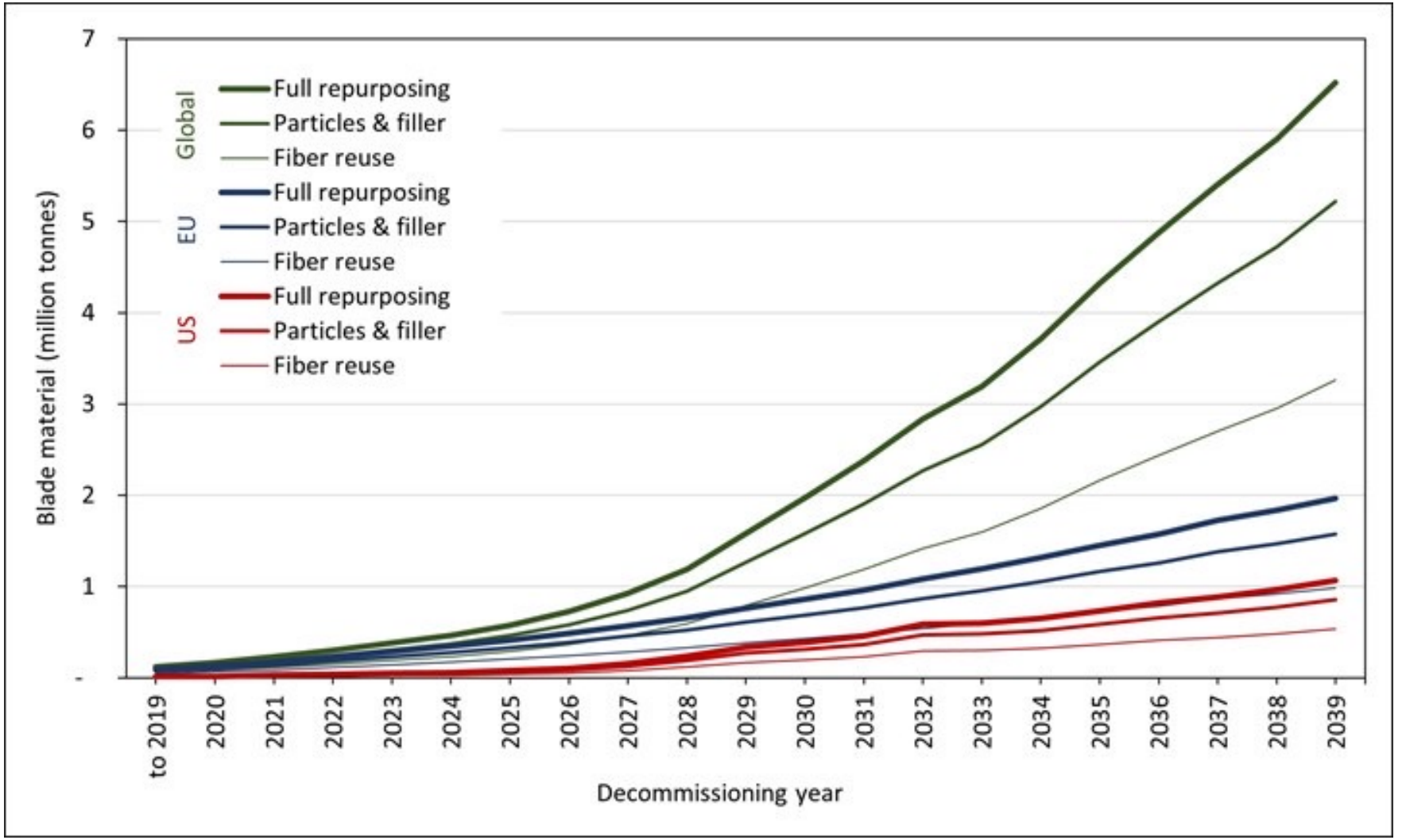
Wind Blades in Landfill
(Bloomberg, 2020)

Circular Economy:





European Waste Hierarchy, in the context of wind turbine blade End of Life (Nagle et al., 2020)



This graph estimates the amount of material that can be diverted from landfills or incinerators as a function of the different technologies for converting the blade composite material to usable "second-life" products in a circular economy, based on a 20-year service life and a 10t/MW blade conversion factor. Energy recovery is not regarded as material reuse. (Bank et al., 2021)

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Challenge:

Repurpose Construction Waste at an element scale

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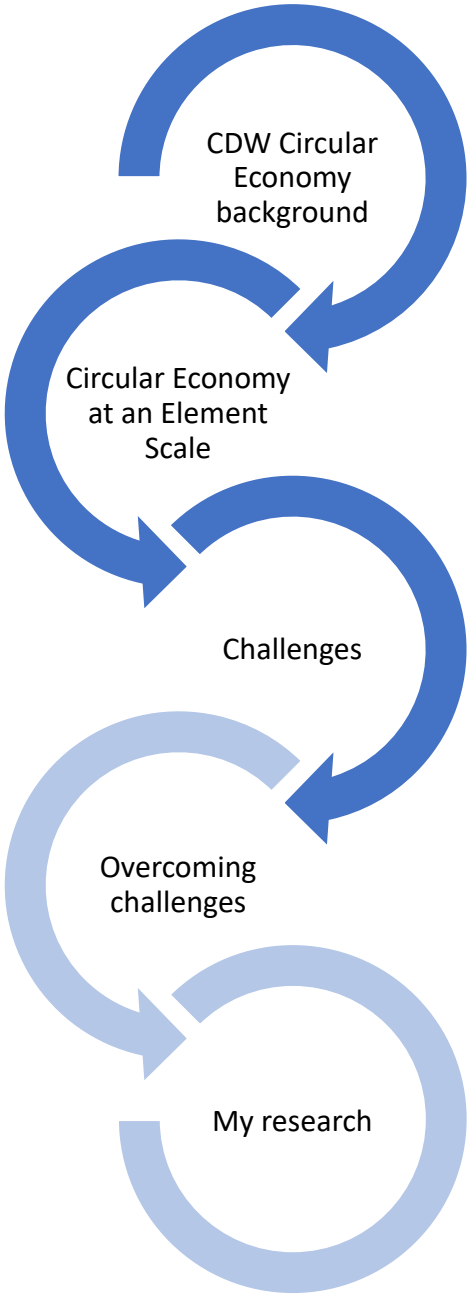


Literature Review

Circular Economy in Construction Demolition Waste:

Current research focuses on deconstruction as reverse construction to salvage infrastructure material (Ramirez-Tejeda et al. 2017, Joensuu et al 2020, Berg et al. 2021)

- Aggregate scale: Recycled aggregate for concrete blocks (Chu et al. 2021)
- Molecular scale: Recycling mining and construction waste as temper in clay bricks (Marrocchino 2021)

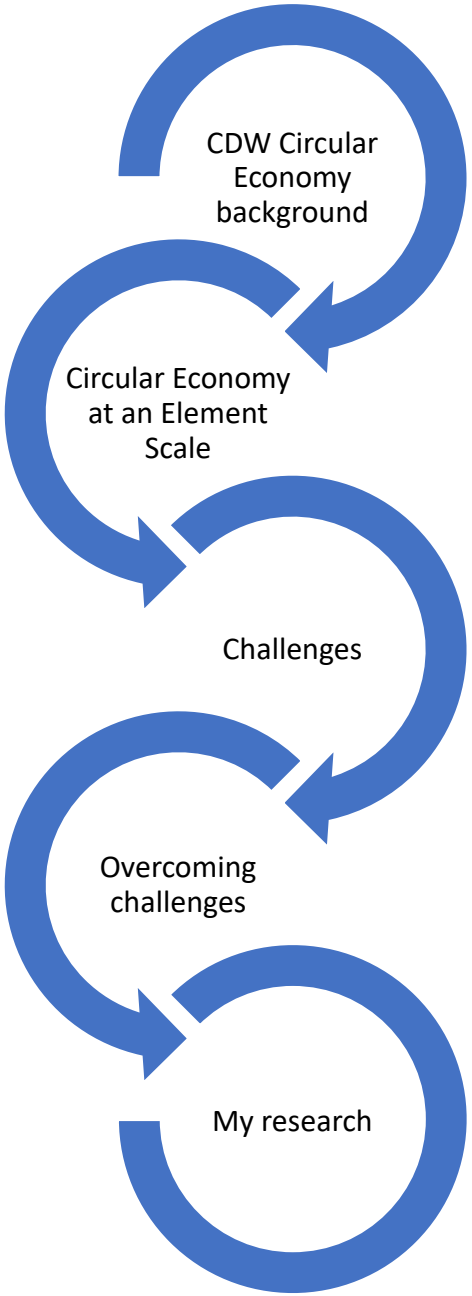
Circular Economy at an Element scale:

Reuse of Wood studs (Diyamandoglu and Fortuna 2015)

Challenges:

Inefficiencies in data Exchange Between Stakeholders:

- Inefficient and slow Stakeholder involvement and Information communication issues (Volk et al. 2014, Jayasinghe et al. 2019)
- Lack of education and personnel training



Literature Review

Overcoming Challenges:

Frameworks to overcome information exchange challenges:

- Current frameworks in construction demolition waste (CDW) (van den Berg et al. 2020, Jayasinghe et al. 2019)
- Design frameworks must adapt to deal with the geometry, properties and supply chain associated with structural elements from CDW (Ali 2017)

EPRI (2020) developed a techno-economic analysis (TEA) framework for the recycling of thermoset composite materials.

My Research:

Goes beyond EPRI (2020) by moving past recycling and disposal alternatives to repurposing options through a material, cost, and ecological process model.

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  - **Case study – BladePole (Patent: Al-Haddad et al. 2021)**
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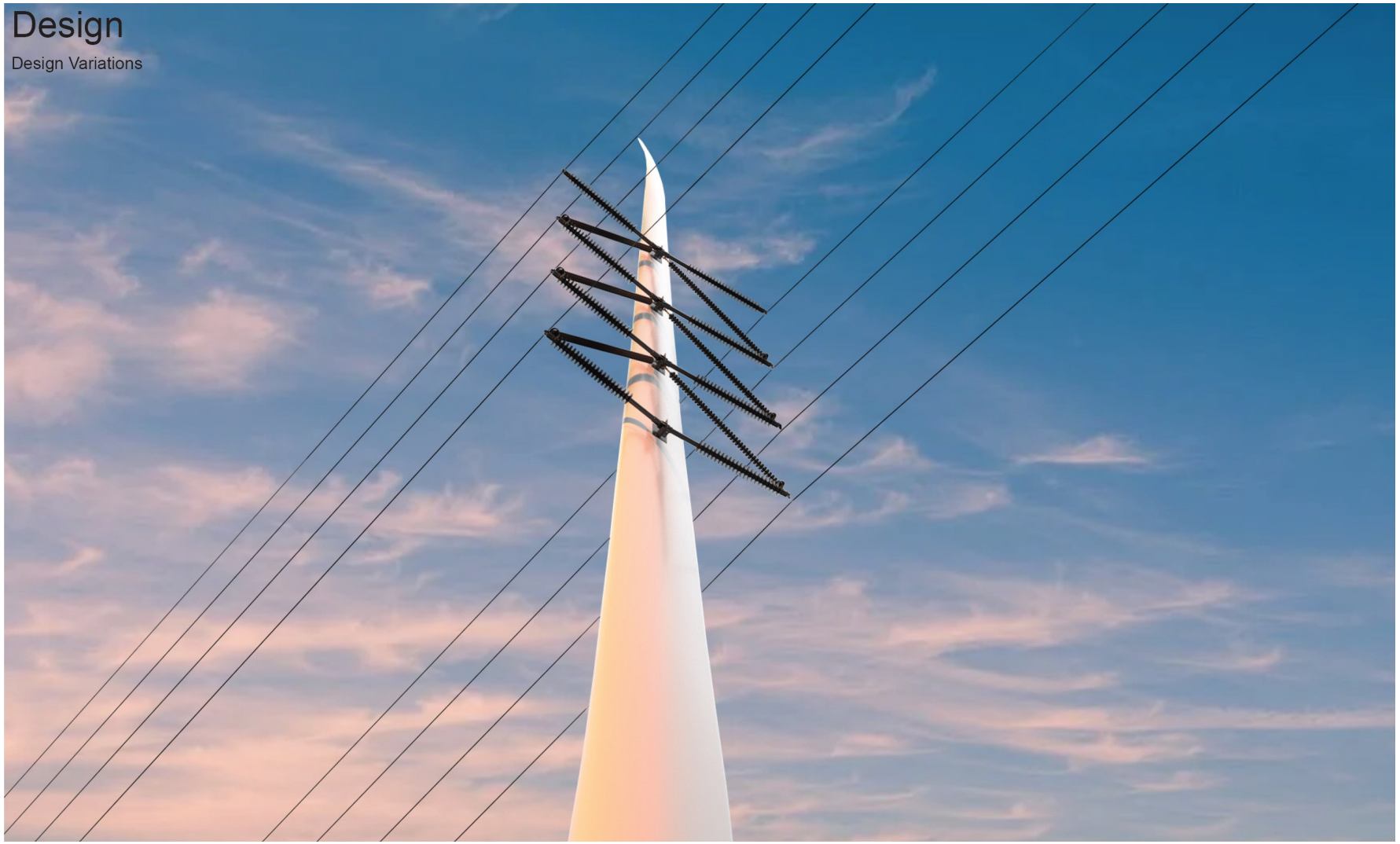
The BladePole as a Solution to the Waste Problem



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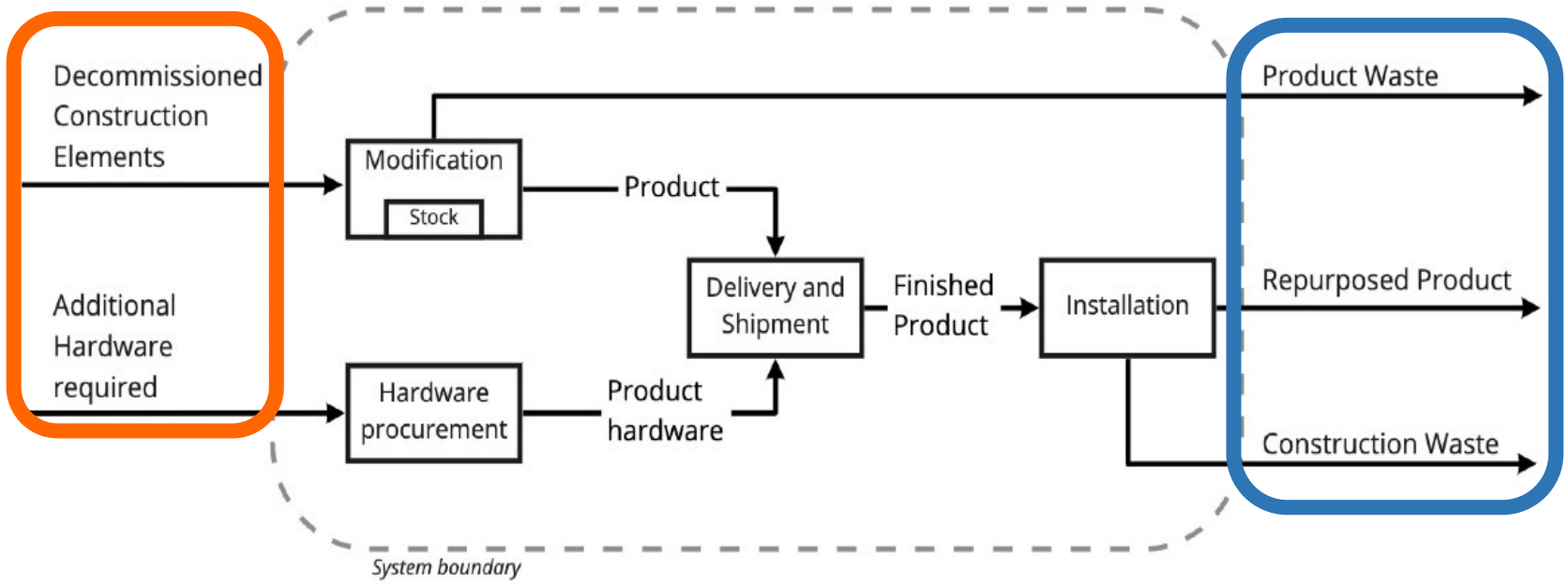
Material Flow Analysis (Brunner & Rechberger 2017)



MFA adapted from Brunner & Rechberger (2017) for repurposing at element scale (Henao et al. under review)

To capture the changes of material as it moves through the economic system.

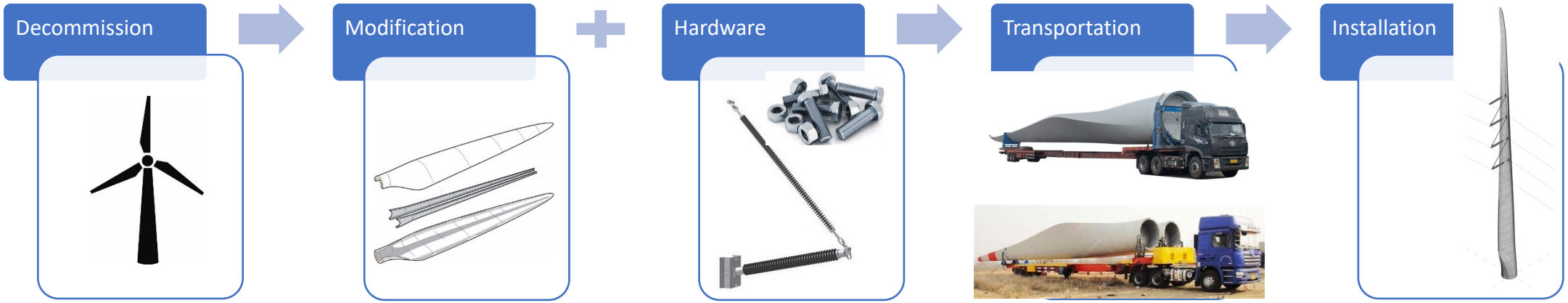
Inputs:

Decommissioned construction elements, additional required hardware.

Sinks:

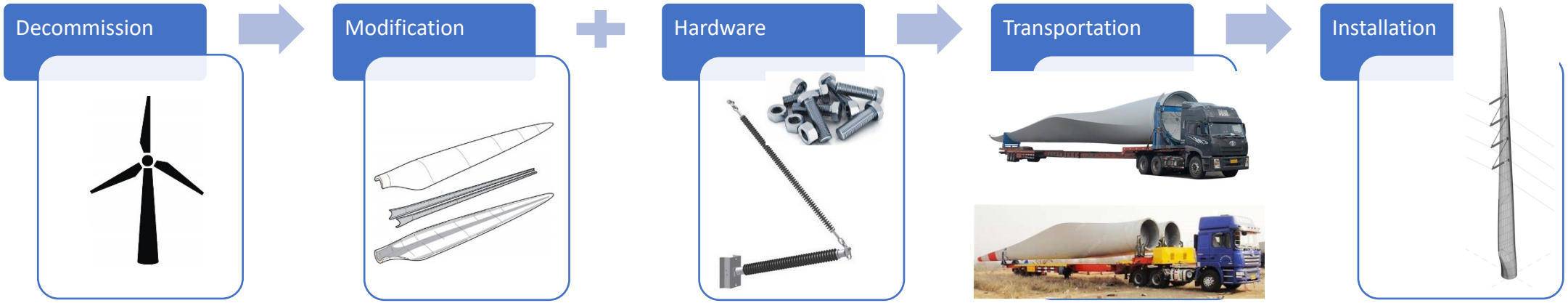
Repurposed products and waste products

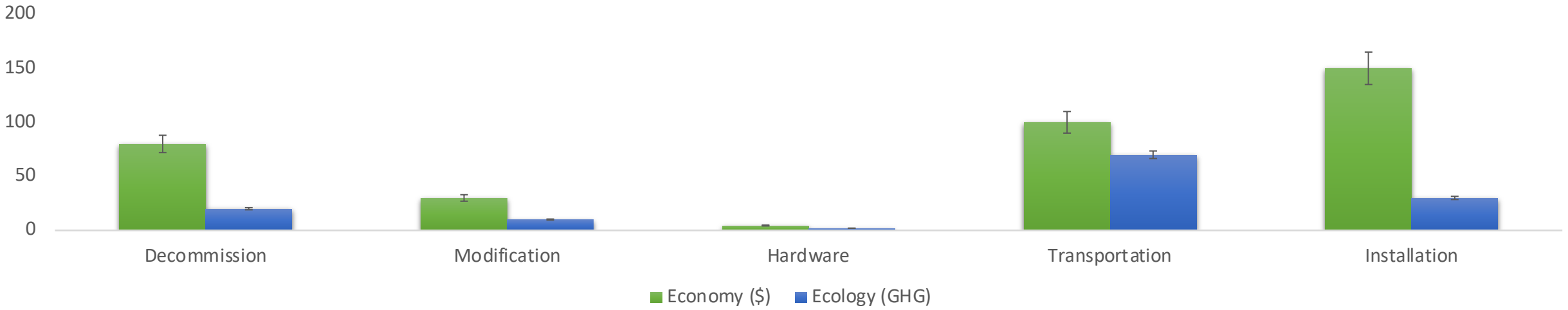
BladePole Process Model



Similar to Cooperman et al (2021) and James (2014), I intend to obtain the material, cost, and environmental information from experts in the decommissioning, transportation, hardware, and installation industry. Part of my research will be to develop methods to gather and validate this information.

BladePole Process Model





(Henao et al. under review)

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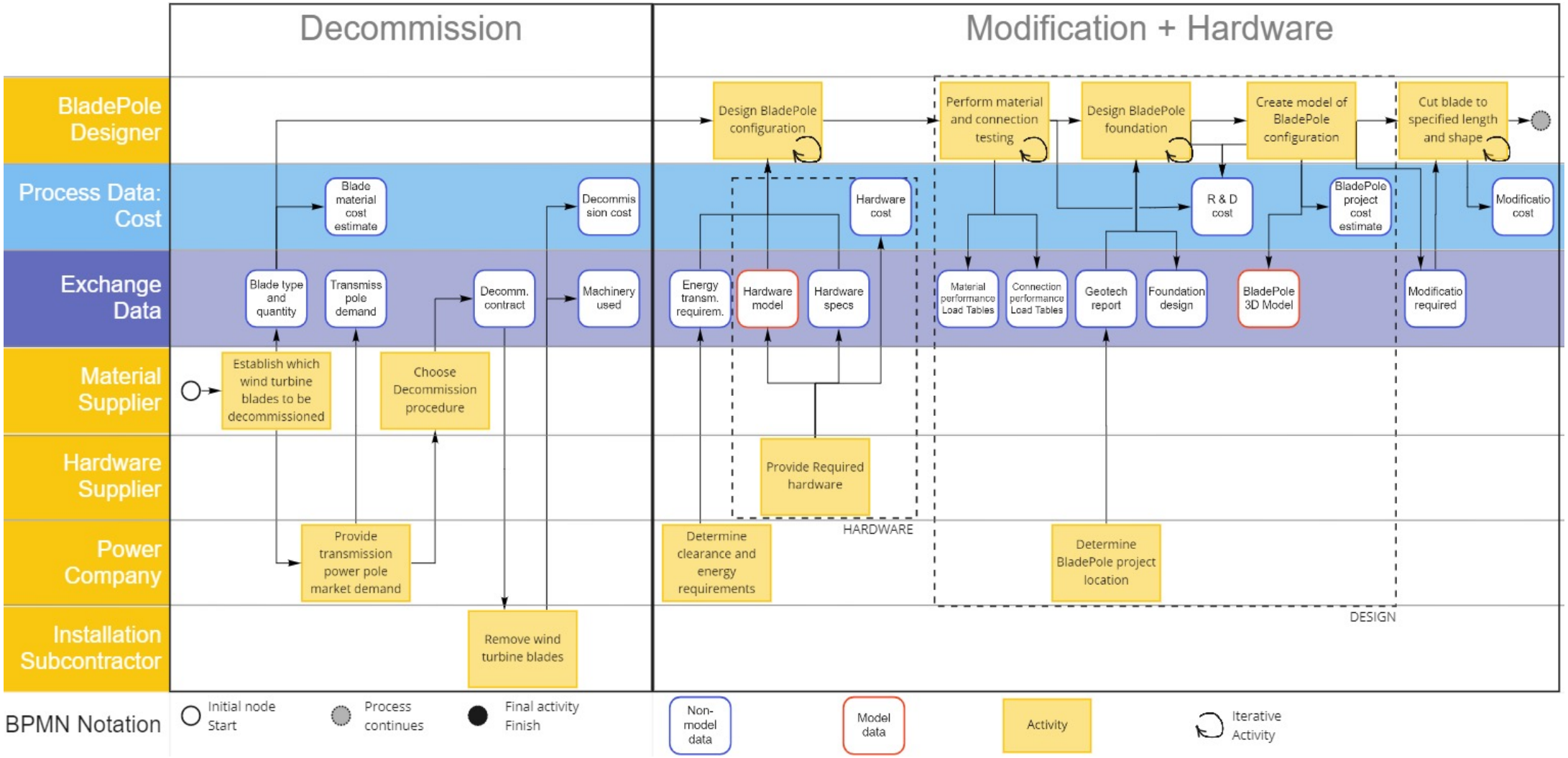
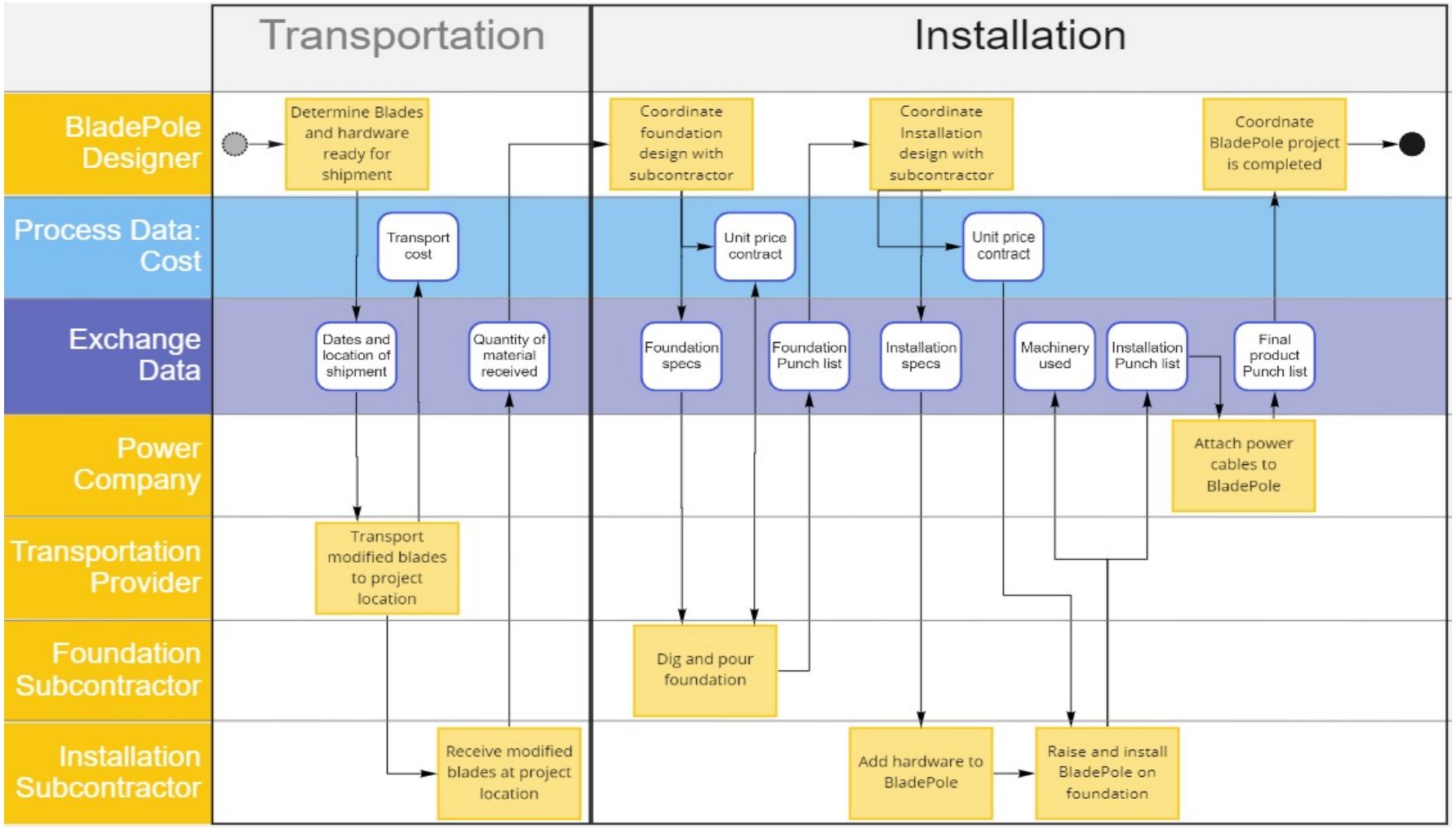
BPMN-based framework: Stakeholder Processes and Exchanges



(Henao et al. Under Review)

BPMN-based framework: Stakeholder Processes and Exchanges



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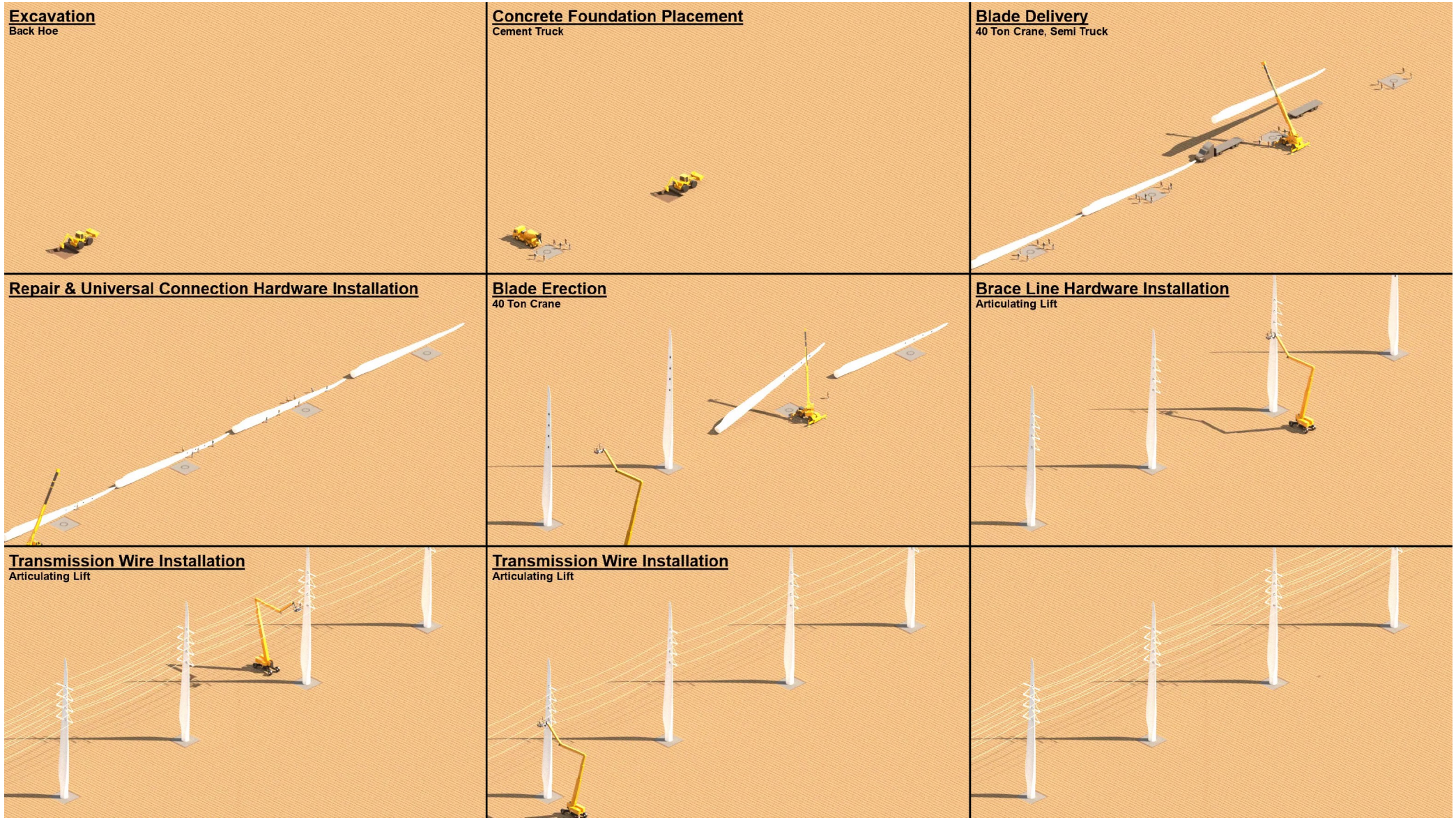
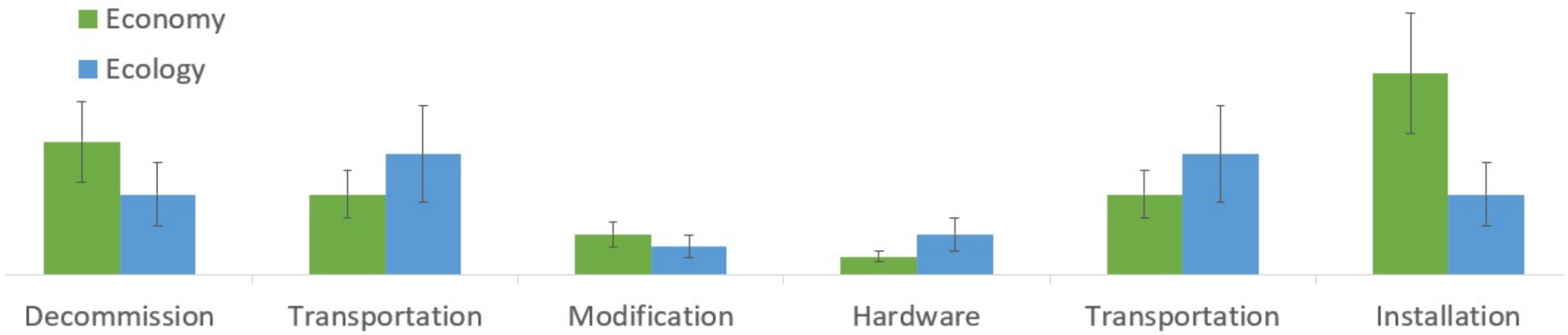
Transportation and Installation



Process Data Flow and Exchanges

This process model can help improve the information communication process between stakeholders and reduce costs:

- Each stakeholder can add material, time, cost, and environmental information
- Each stakeholder fills the BPMN node that pertains to their services



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Anticipated Contributions

Theoretical Contribution:

- Provide a framework for assessing the feasibility of repurposing construction waste elements.
- Validating the boundary conditions required for element scale repurposing of construction demolition waste.

Practical Contribution:

- The output of the data collection and analysis can be communicated to stakeholders for cost analysis and to improve supply chain.
- Comparison between cost matrices of different power poles materials

Steel 

Concrete 

Wood 

Coming Up – March 2022

Full-scale testing of braced line post assemblies for gravity and wind loads.

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Thank you!

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