# Advancing the Science of Domicology


**domicology.msu.edu**

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# Domicology….what is it?

## Domicology:

The study of the economic, social and environmental factors relating to the "life cycle" of structures.

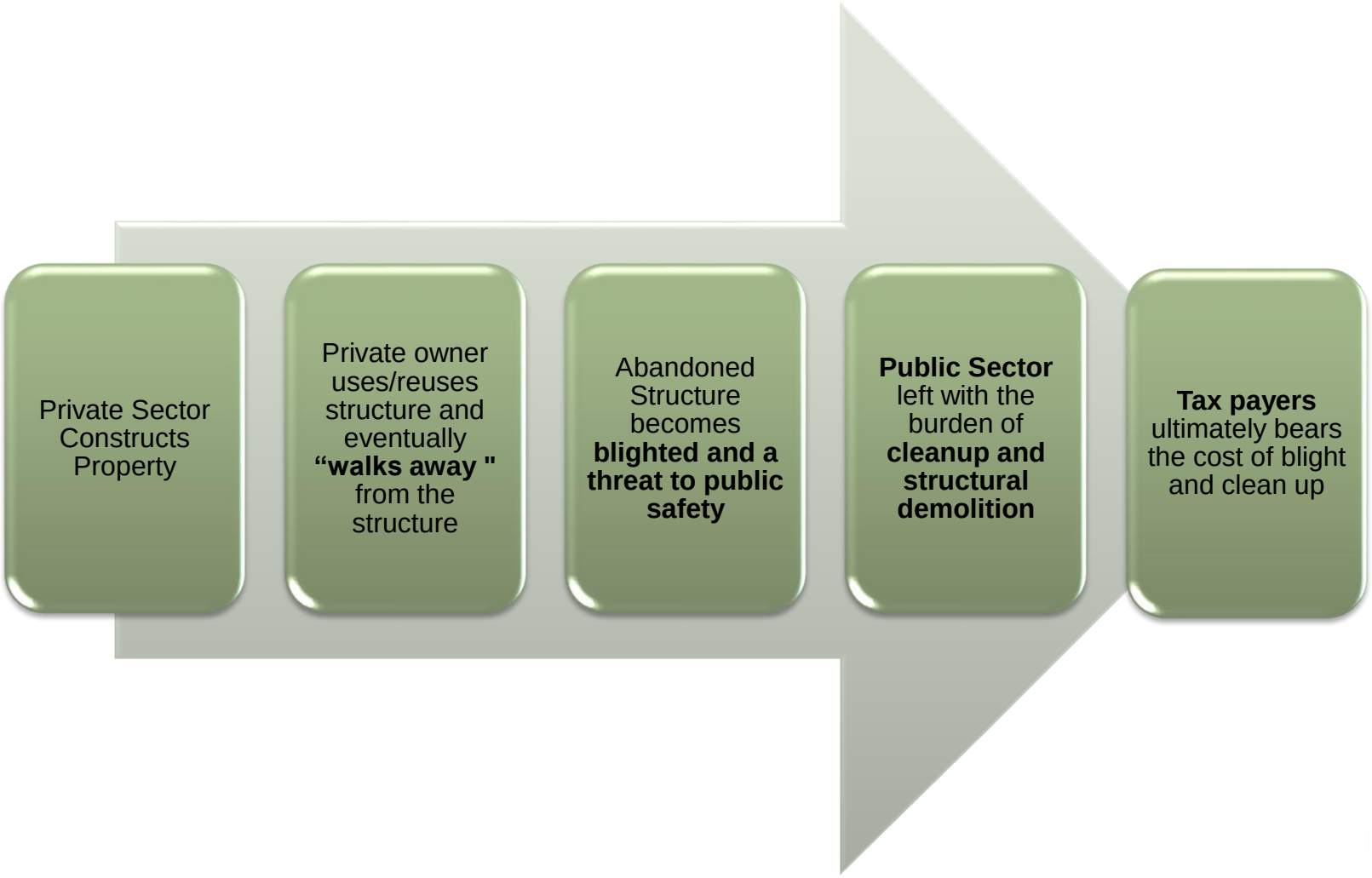
## What might Domicologists do?

- Examine the life cycle continuum of building and infrastructure use and abandonment from planning, design, construction, building use, reuse, abandonment, demolition/deconstruction and material reuse.

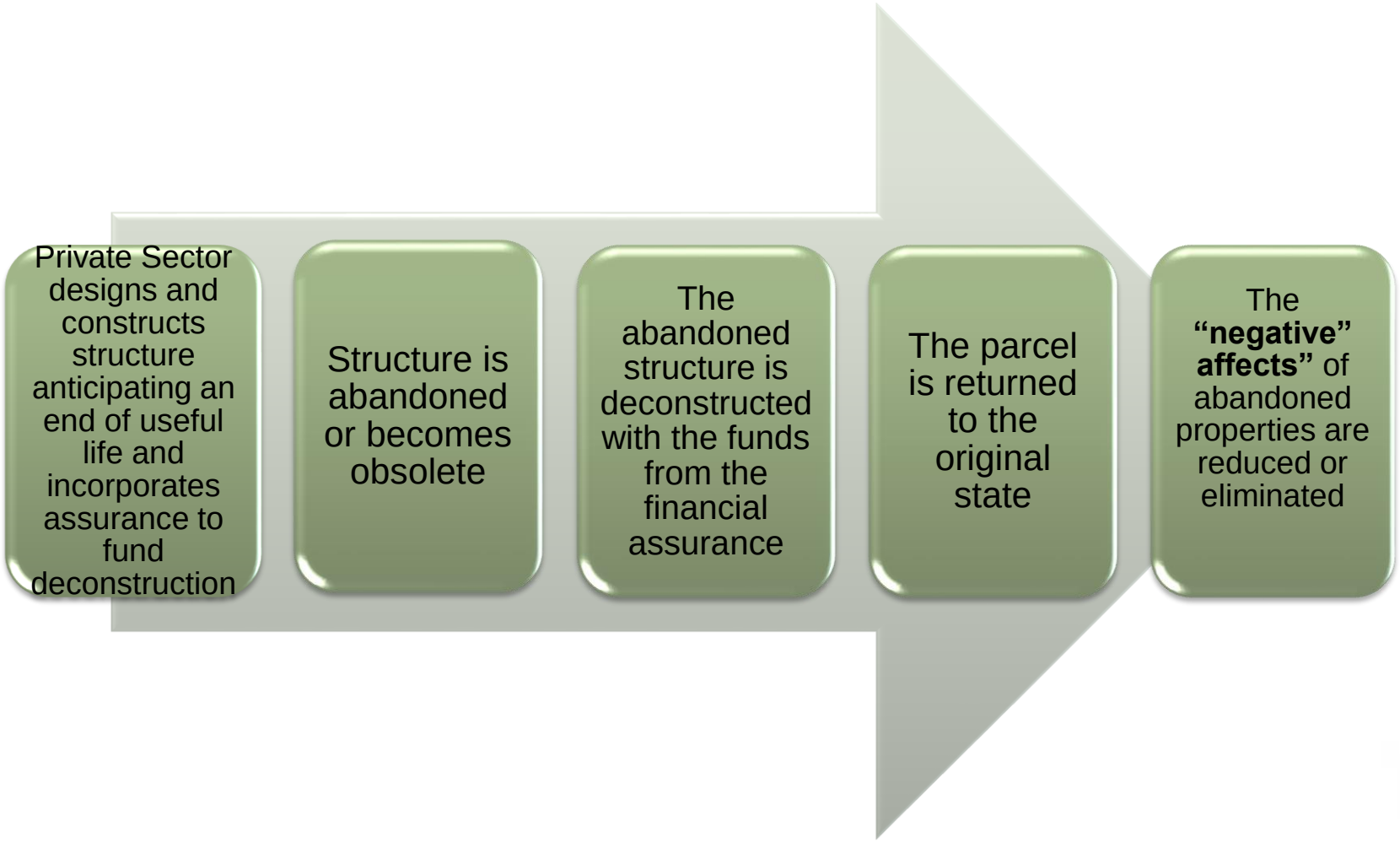
- Identify potential innovative tools, models, policies, practices and programs that can sustainably address structural life cycles and abandonment.

- Conduct research on the technical, economic and policy challenges present in structural abandonment and seek to reduce the negative social, economic and environmental impacts associated with structural abandonment.

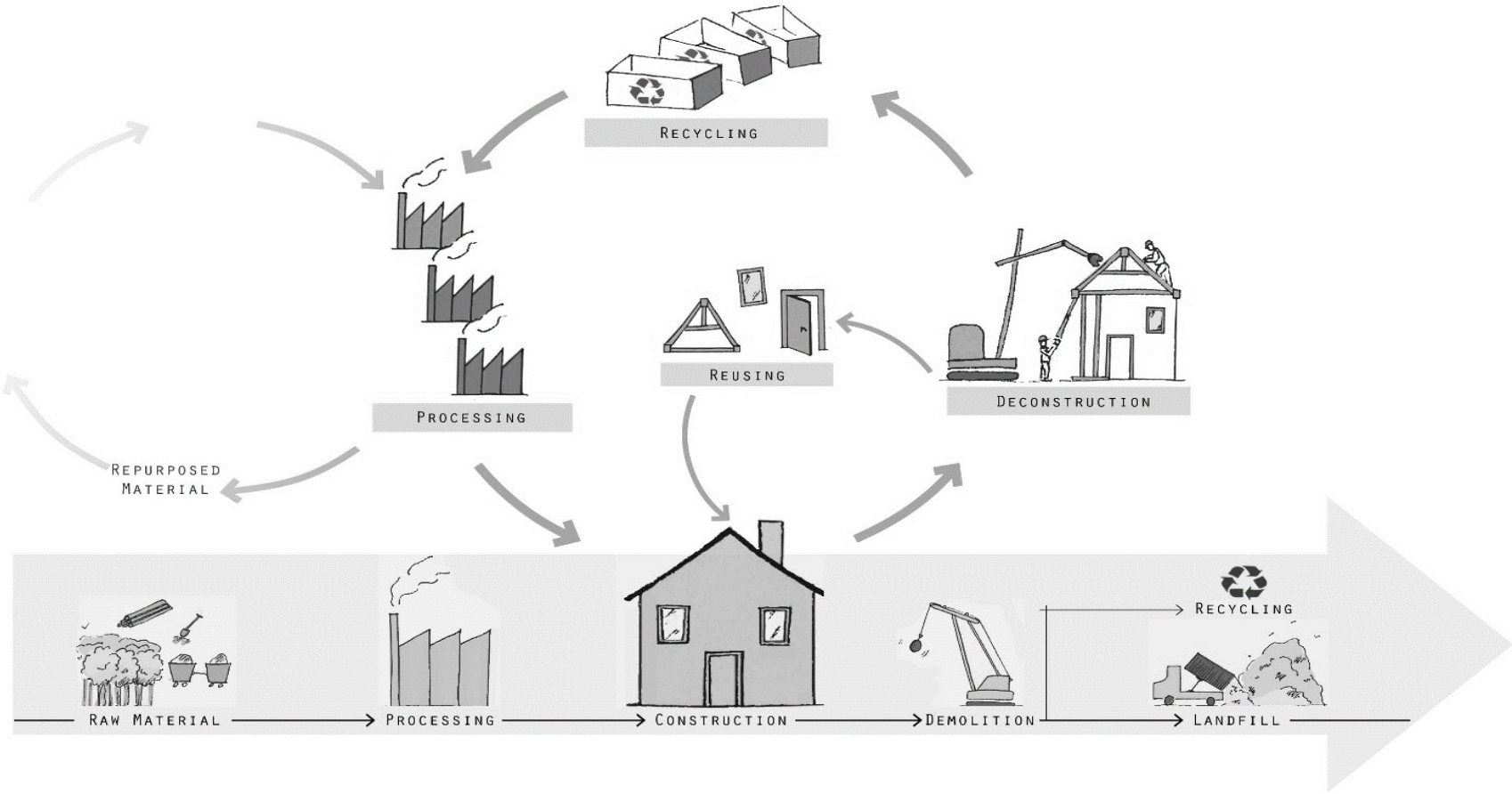
# Nature of the Challenge



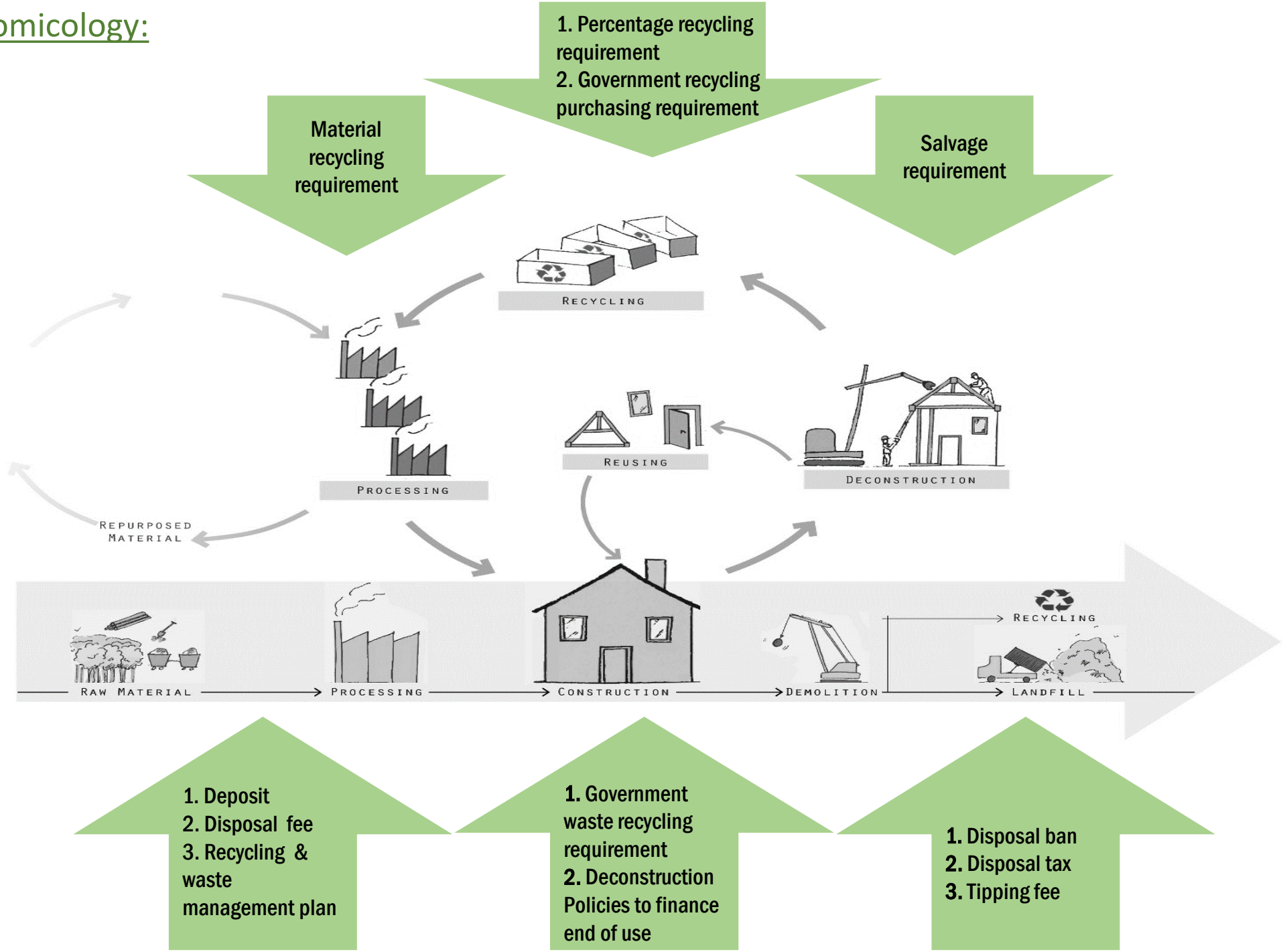
# The Alternative Paradigm



# Domicology: An alternative paradigm for structures



# Policy Inputs In Domicology:



# Thank You!

## Up Next:

**Dr. Matt Syal, MSU Construction Management**

**Dr. Venkatesh Kodur, MSU Civil Engineering**

**Dr. George Berghorn, MSU Construction Management**

**Dr. Julie Brockman, MSU School of Human Resources and Labor Relations Resources and Labor Relations**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# Removal of Abandoned Properties

# Deconstruction vs. Demolition: Process, Cost and Time

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2016

# Overview

- 245,000 residential structures and 44,000 commercial structures are demolished each year in the US
- US-EPA estimates that 136 million tons of Construction & Demolition (C&D) waste is generated annually and over 90% is due to renovation and demolition
- Construction-related waste constitutes one- fourth of landfill waste in the US

*References: Bradely. et al., 2003, US EPA, PPRE (*http://www.p2rx.org/*)*

# DEMOLITION vs. DECONSTRUCTION

- Knocking down of a building and hauling materials to landfills or to be recycled – generally equipment intensive and quick

- Deconstruction is a process of selective /careful building disassembly in order to recover the maximum amount of materials for re-use – generally labor intensive and takes much longer

# Cost Comparison: 1,476 SF House

| Cost Element | Average Demolition Costs | Average Deconstruction Costs |
|---|---|---|
| **Size (SF)** | **1476** | **1476** |
| **Labor/Equipment ($/SF)** | 1.74 | 3.64 |
| **Testing for Asbestos & Lead ($/SF)** | 0.97 | 0.97 |
| **Disposal ($/SF)** | 2.17 | 0.97 |
| **Other Costs: permit, etc. ($/SF)** | 0.48 | 0.89 |
| **Gross Cost ($/SF)** | **5.36** | **6.47** |
| **Salvage ($/SF)** | 0.00 | 3.28 |
| **Net Cost ($/SF)** | 5.36 | 3.19 |
| **Net Cost ($/SF) 50% Salvage** | **5.36** | **4.83** |

(Guy & McLendon 2000; Dantata *et al.* 2004)

# Research Questions

- Obstacles to Deconstruction despite equal or lower costs and environmental benefits
- Time required for deconstruction vs. demolition
- Training and skill of workers
- Design for Deconstruction (DFD) - Design, material selection, and construction in a way so the buildings are conducive to Deconstruction
- Supply Chain of deconstructed material including facilities and transportation
- Others: Regulations, Incentives, etc.

# Thank You!

# Advancing Domicology for Sustainable Construction

**Venkatesh Kodur**
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Michigan State University

# Domicology

- **Domicology**
  - Study of policies, practices and consequences of structural abandonment

- **Sustainable design**
  - Should include consideration of lifetime resources (e.g., energy, raw materials), plus handling of construction and demolition waste

- Current practice - Not much consideration for sustainability issues arising from abandonment/restoration of structures

- Abandonment – low probability, but high consequence event

- Why abandonment?
  - Major attacks/terrorist incidents (9-11)
  - Wars/Economic migration – (Ex. Syria (2015), Sri Lanka (1980's))
  - Catastrophic events – Earthquakes (Ex. Taiwan, Turkey), Tornados, Hurricanes (Ex. New Orelans, LA)
  - Accidental events – Fire, Blast (Ex. Oklahoma, OK)
  - Economic downturn (Ex. Detroit, MI)

  - Structures are the secondary victims

  - Leads to abandonment of buildings/structures

# Current Practice – Abandoned Structures

- Abandonment
  - Current practice - Demolition of structures – the preferred solution.

**Consequences of Demolition – Environmental, Safety, Economic**

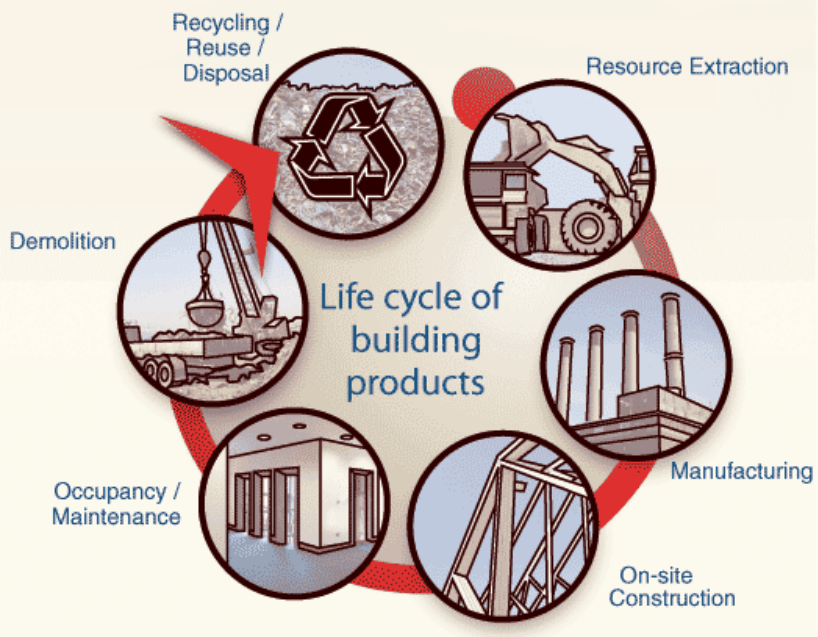
- Waste - Land-fills
  - 25 to 40% of the national solid waste stream is construction - related waste and only 20% of construction waste or demolition debris (C&D) is actually recycled (US)
  - 40% of landfill waste, directly attributed to building and construction (Australia)
  - 9/11 incidents (2 millions tons of debris in 9 months)
- Too much resources for recycling
- Air/Water pollution from construction/demolition sites (Ex. Delhi, Beijing)
- Safety of workers, commuters during demolition
- Hazardous to health/environment
  - Asbestos, lead (ex. fire fighters health (post 9-11))

- Direct costs/time (life cycle costs) for demolition - High
- indirect costs, life cycle costs - Very high

- Not accounted for in current design/practice
- Not a sustainable solution

# Solutions to Abandonment

- Current practice – demolition is the 1st solution to abandoned structures
- Demolition/removal should be the last resort
- Alternative solutions
- Refurbishing/Retrofitting of structures possible
  - Structures can be retrofitted/refurbrished for different scenarios
  - Different purposes/occupancy (ex. school to hospital)
  - Different loading conditions




- Need to develop unique strategies/best practices for refurbishing/retrofitting abandoned structures
  - Cost effective approaches and techniques can be viable alternative to demolition

- Need approaches to incorporate Impact of structural demolition during initial design of project
  - Should be part of life cycle costs`

# Solutions to Abandonment

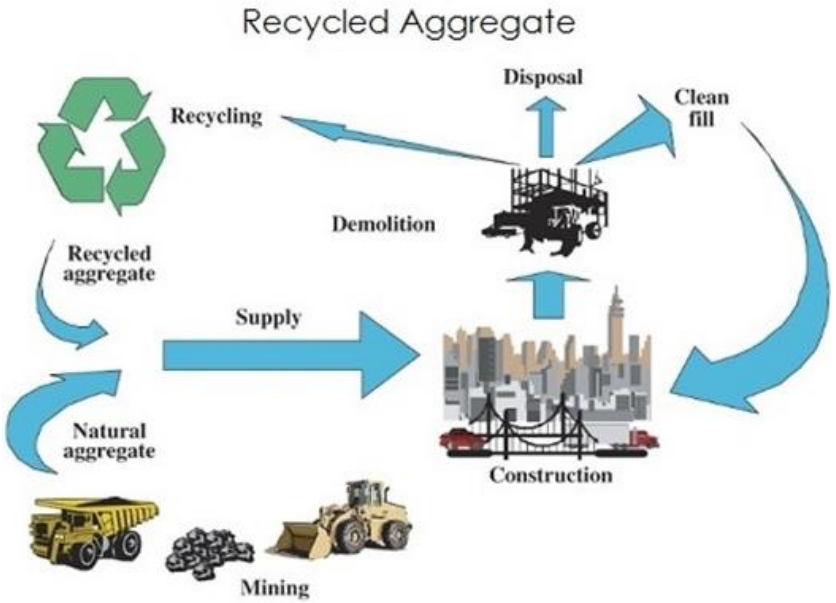
- Better design features/construction practices
- Structural design
  - Should encompass techniques to deal with abandonment of structures
- Unique solutions for different construction types/practices
- Steel structures
  - Bolted connections vs welded connections
- Concrete structures
  - Prefabricated construction
- Masonry/wood structures
  - Standardize section sizes
- Need best practice documents
  - design rules & practical guidelines

# Solutions to Abandonment

- Current practice – not much research or techniques to deal with abandoned structures or process of demolition structures
- Solution – Reusing, Refurbishing, Retrofitting & Recycling of structures, components & materials
- Steel structures
  - Reuse of structural components
- Concrete structures
  - Recycling of materials (aggregates)
  - Dwindling of resources (ex: sand Singapore)
- Masonry
  - Recycling of materials (Bricks)
- Need techniques and best practices documents for reuse/recycling
- Need machinery/tools for recycling of materials, sorting of construction waste
  - Reuse in reconstruction, or other applications
  - Recycle for construction products
  - Recycling of materials

# Need Strategies for Advancing Abandonment

- Advancing Domicology for Sustainable Design/Construction
- Refurbishing/Retrofitting strategies
- Reuse of structural components
- Recycling of materials for reconstruction
- Recycling of materials for other applications




- Develop life cycle cost models
  - Impact on sustainability

R&D is the key to develop unique solutions

- Challenges
  1. Awareness: policy makers, public
  2. Training (policy): engineers, city/building officials
  3. Training (techniques): construction workers
  4. Funding for research
  5. Construction industry: unorganized sector

**Developing solutions to abandonment is key to achieve overall sustainability**

- Will have significant economic benefits

# Thank You!

# Domicology: Changing the CEM Paradigm

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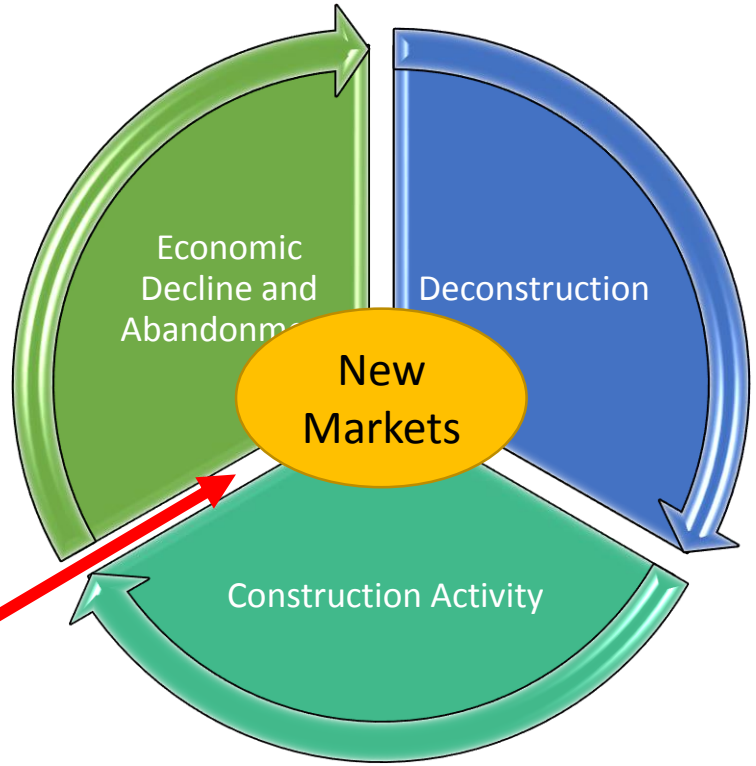
Assistant Professor of Construction Management
School of Planning, Design & Construction

# Shifting the CM Paradigm

- Domicology changes the role of construction management in community and economic development

**Traditional Concept Model**


**New Concept Model**




**Eventually the cycle is broken**

# Materials and Supply Chain

- Materials and markets are at the core of this paradigm shift
- Material quality and quantity varies by “skim”
- 1st Skim – fixtures, copper, commodities
- 2nd Skim – More difficult to remove commodities
- 3rd Skim – High volume, low value materials

# Materials and Supply Chain

- Upper Great Lakes has an abundance of such "3rd Skim" material
  - 'Other vacant' = 264,660 homes
  - Potentially-available lumber **~1.5 billion BF**
  - Estimated value **~$3.45 billion**

- Other high-value materials include bricks/blocks, flooring, steel scrap etc. Concrete had additional costs for processing before reuse or sale as aggregate

| Salvagable Materials Available after 3 Skims. | |
|---|---|
| **S.No** | **Material name** |
| 1 | Framing Lumber |
| | 1.1. Size 2*4 |
| | 1.2. Size 2*8 |
| | 1.3. Size 2*10 |
| | 1.4. Size 2*12 |
| 2 | Plywood |
| 3 | Oriented Strand Boards |
| 4 | Bricks |
| 5 | Blocks |
| 6 | Masonry Clay bricks |
| 7 | concrete |
| 8 | Drywall ( Gypsum board) |
| 9 | Asphaltic Shingles |
| 10 | Wooden Roof Sheathing |
| 11 | Structural Steel |
| 12 | Flooring |
| | 12.1. Wooden |
| | 12.2. Linoleum |
| 13 | Hardwood |
| 14 | Barn Wood Siding |
| 15 | Wooden panels |
| 16 | Stones |
| | |

# Materials and Supply Chain

- Mixed picture on markets
  - Highly location and public policy- dependent
  - Retail vs. industrial; material-specific and limited
  - Transportation modes

- Research needed
  - Location of markets for difficult materials
  - Shipping modes and costs


# Shifting the CEM Paradigm - Revisited

- How do we shift our paradigm “norms” in CEM and related fields?

- Potential research areas
  - Predictive cost models
  - Time studies/scheduling concerns
  - Safety practices and models
  - Impact of DFD on (de)construction
  - Assembly construction and performance
  - Post-occupancy surveys
  - Spillover effect
  - Life cycle costs

# Thank You!

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supplier/
vendor

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Deconstruction is a human activity

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- Labor Cost
- Training
- Health
- Safety
- Job classification
- Crew design
- Organizational Work Design
- Organizational Processes
- Recruitment
- Management
- Support resources
- Macro Design

# Deconstruction is a human activity