DYNAMIC FIBER FLOWS MODEL

Measuring the complex behaviors and trade-offs associated with changes to paper recovery and recovered fiber utilization in paper products based on system-wide interactions that take place within the paper value chain.

WHY

Recovering paper for recycling has multiple environmental benefits. Diverting paper from the landfill avoids greenhouse gas emissions that contribute to climate change. In addition, utilizing recovered fiber in products extends the fiber supply and saves landfill space. But the benefits of replacing virgin fiber with recycled fiber in paper products can vary widely, depending on the source and use of those types of fibers. Current research and calculators are limited in that they do not capture the system-wide consequences of replacing virgin fiber with recovered paper. The Dynamic Fiber Flows Model is a new framework, based on published, peer reviewed research that recognizes the complexities and dynamics across the entire paper product system, from fiber sourcing to end-of-life.

INTERACTIONS

The Dynamic Fiber Flows Model identifies the market interactions associated with paper recovery and utilization, which are based on both the economic and technical characteristics of materials. The model captures decision-making among types, quantities and sources of various grades of fiber consumption to meet their product demand and specification given technological constraints, fiber processing capacity, the availability of fiber grades, and market values.

This new framework consists of two steps: calculating 1) new fiber flows as a result of a change introduced to the pulp and paper industry and 2) energy and GHG emission changes as a consequence of changed fiber consumption pattern through the life-cycle of paper products.

CASE STUDIES

Because of the complex interactions, the multiple variables at play, and the cascading effects that occur within fiber consumption and production of different paper product categories, AF&PA is presenting the results of the research project in the form of case studies. Each study represents a question, or a scenario related to a potential change of paper recovery or recovered paper utilization. By putting the quantitative results into context, the case studies may be useful to better inform policymakers and corporate decision makers regarding system-wide environmental effects within their supply chains.

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DYNAMIC FIBER FLOWS MODEL

DYNAMIC FIBER FLOWS Q&A

Why did AF&PA develop this recovered paper research project?
There has been much debate over the years about environmental benefits of increasing the utilization of recovered fiber in paper products, with many policy makers and corporate procurement professionals believing that more recycled content is always better. These impressions were often based on available tools or calculators that compared products with different levels of recycled content. Simplistic tools, however, cannot adequately capture the effects that occur in a complex recovered fiber system. We wanted to explore a more comprehensive way to evaluate the real-world environmental consequences of changes to paper recovery and utilization and chose MIT to lead the research.

Why MIT?
Researchers at MIT were pioneers in Systems Dynamics Thinking and are at the forefront of modeling change within intricate systems. The processes and material flows involved from fiber acquisition through product production, recovery, reuse and end-of-life are very complex. MIT had experience in complex systems, plus they were able to combine Systems Dynamics with consequential life cycle assessment methodology to create a whole new way of examining the recovered paper system.

What makes the Dynamic Fiber Flows Model unique?
The model advances the perspective from a traditional static comparison of product attributes to assessing the consequences of changes that occur throughout the product system. It recognizes that shifts in recovered paper utilization or collection do not occur in isolation, but have cascading effects across many links in the value chain. The model quantifies those effects for the entire system, providing a comprehensive and holistic viewpoint to simulate real-world outcomes.

What does the model measure?
The simulation model is designed to quantify the effects of a change to recovered paper utilization or a change in paper recovery relative to a baseline level, which currently is 2017. It first models how the virgin and recovered paper flows would change in response to a change introduced in the system (e.g. increasing the recycled fiber content of printing papers by X %).Then, the model calculates how biogenic and fossil fuel-based energy use and GHG emissions would change as a result of the new fiber flows from the forest to end-of-life of the product.

What types of paper are included in the Dynamic Fiber Flows Model?
The products in the model are containerboard, paperboard, tissue, freesheet printing papers, and mechanical printing papers/newsprint. In addition, the model includes recovered paper grades- mixed paper, Old Corrugated Containers (OCC), high-grade deinking, newsprint, and pulp substitutes.

Is the Dynamic Fiber Flows Model intended to replace current tools?
No, this model can't really be compared with other tools or calculators because it takes an entirely different approach. While other tools may make value judgements based on environmental attributes they assign for product comparisons, this model does not compare products, but reveals trade-offs and consequences associated with a specific change in the system. Unlike other tools or calculators, this model differentiates among the various types of recovered paper that can be recycled to make new products, and recognizes constraints in fiber availability, suitability, technology, and economic tradeoffs that occur in real-world scenarios.

How will the Dynamic Fiber Flows Model benefit the industry?
The intent of the model is to inform policy makers or decision makers with paper in their supply chains of the system-wide consequences and trade-offs to changes in paper recovery and recovered paper utilization. The model reveals that recovered fiber utilization or paper recovery changes do not occur in a vacuum, but cascade throughout the system in response to those shifts. Omission of the system-wide effects of those interactions can result in misleading conclusions and unintended consequences. This more comprehensive perspective can benefit stakeholders by helping them make more informed decisions.

Why are the results of the Dynamic Fiber Flows Model presented as case studies?
As the name suggests, there are lots of dynamics involved in credibly assessing the fiber flows within the paper value chain. Because of the complex interactions, the multiple variables at play, and the cascading effects that occur within fiber consumption and production of different paper product categories, the model results are best presented in the form of case studies. Each study represents a question, or a scenario related to a potential change of paper recovery or recovered paper utilization. The quantitative outputs require interpretation. By putting the numbers into context, the case studies may be useful to better inform policymakers and corporate decision makers regarding system-wide environmental effects within their supply chains.

DYNAMIC FIBER FLOWS MODEL

Understanding the effects of changes in paper recovery and recycling

American Forest & Paper Association

Dynamic Fiber Flows Model research sponsored by the American Forest & Paper Association at Massachusetts Institute of Technology’s Department of Materials Science & Engineering.

WHY THE PROJECT WAS INITIATED

The benefits of replacing virgin wood pulp with recovered paper have been the subject of debate for years

- Policy makers and stakeholders have a longstanding belief that increased recycled content is always better
- Increasing recycled fiber use in all paper products is a bedrock advocacy principle for environmental campaigners
- Tools most often used to quantify the benefits of recycled content have a limited perspective and lack a comprehensive understanding of economic and environmental tradeoffs
- Simplistic tools cannot adequately capture the effects that occur in a complex recovered fiber system

THE CHALLENGE

- Changes to paper recovery and the substitution of recovered paper for virgin pulp in products do not occur in isolation- multiple interactions cascade throughout the system
- The fiber value chain is vast and complex, with many interconnected links in the chain
- The benefits of recovered paper utilization can vary widely, depending on the source and use of different types of recovered paper
- Life Cycle analysis alone cannot quantify the consequences and trade-offs that occurs system-wide

A NEW APPROACH BY MIT RESEARCHERS

Combining Life Cycle assessment with Systems Dynamics Thinking

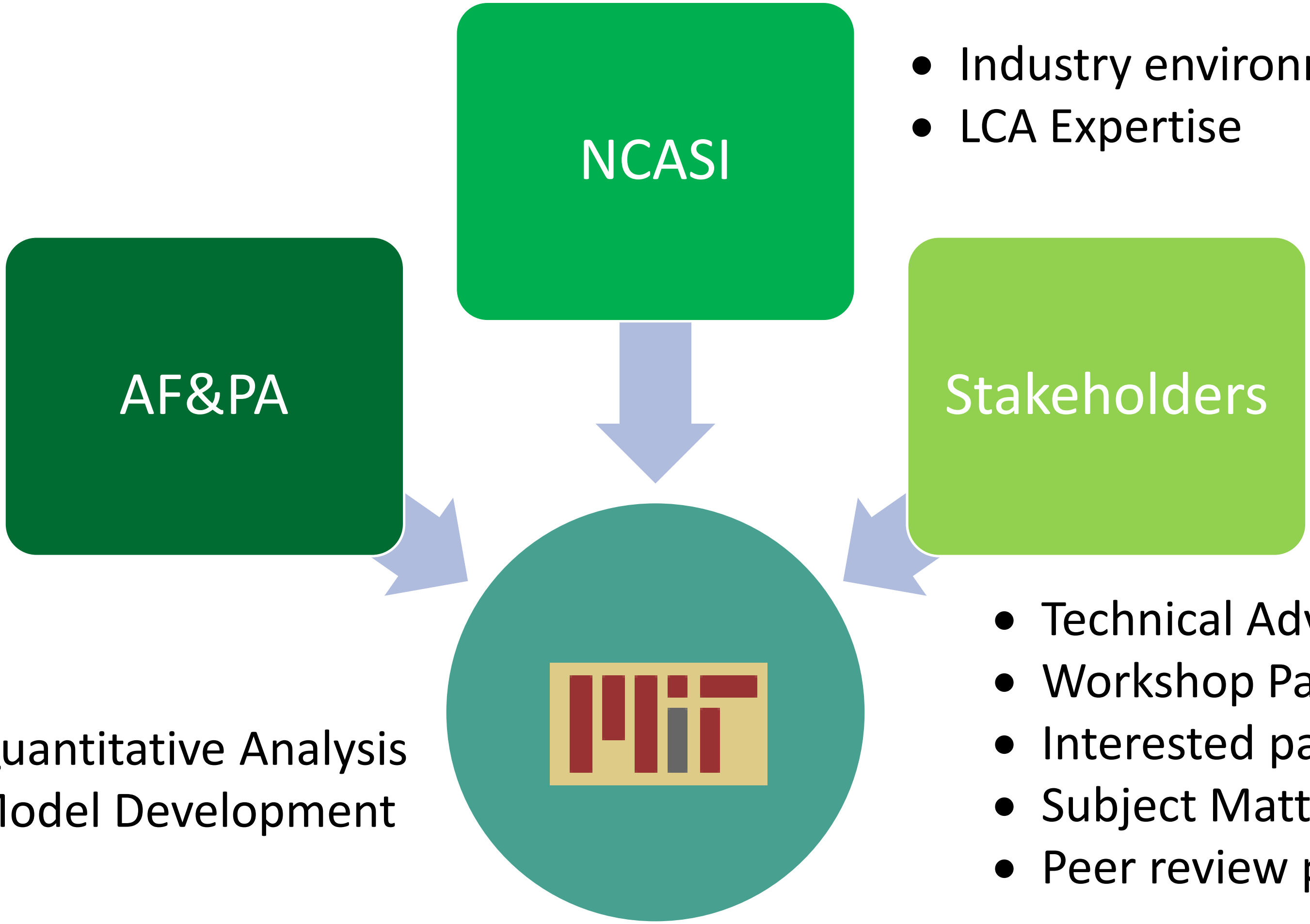
Why MIT?

- Experience in examining complex systems
- Pioneer in Systems Dynamics Thinking
- Materials expertise
- Modeled other industries

MULTI-STAKEHOLDER PROCESS

- Industry environmental data
- LCA Expertise

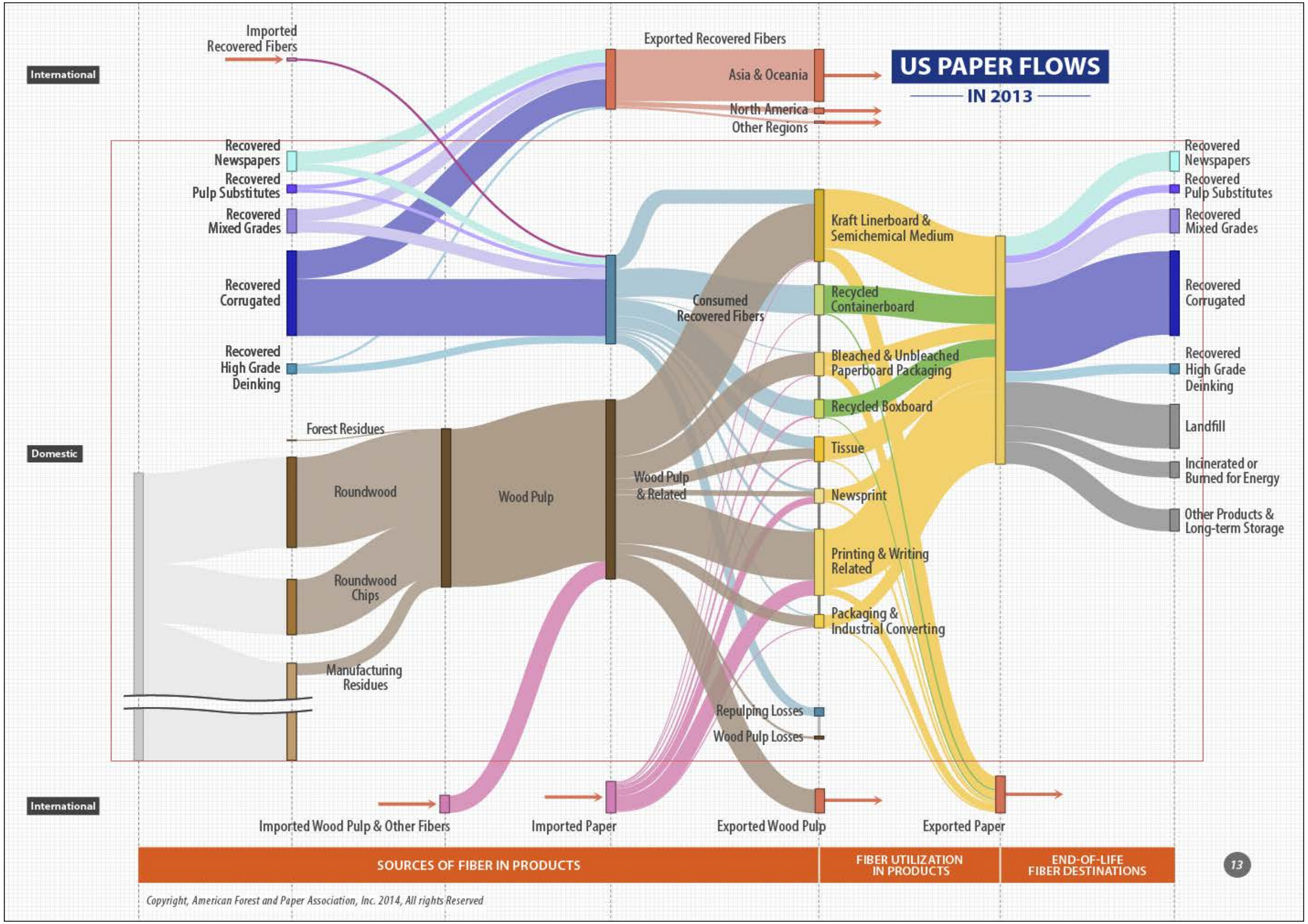
- Industry Statistics



- Technical Advisory Group
- Workshop Participants (Entire value chain)
- Interested parties (EPA, ENGOs)
- Subject Matter Experts
- Peer review panel

- Quantitative Analysis
- Model Development

Phase 1: Mapping the complex fiber flow system



DYNAMIC FIBER FLOWS MODEL

SIMULATION MODEL DESIGN

2. A scenario is introduced (example- what are the effects of increasing the average recycled content of P-W paper by 15%?

Baseline Background Data
(multiple stakeholders and data sources)

- Fiber Balance
- Fiber characteristics
- LCA studies
- Recovery Rates and Collection Channels
- Exports
- Industry Data
- Tech. Advisory Group
- Subject Matter Expert Interviews

1. 2017 data established as baseline based on multiple data inputs

Case Study Scenario

Simulation Model

- Printing-Writing
- Newsprint
- Paperboard
- Containerboard
- Tissue

Revised Fiber Distribution

Impact on paper manufacturing, End-of Life

GHG Impact on Forest, Agricultural

3. The model redistributes fiber flows based on the scenario, then calculates life cycle effects , from forest to end-of-life

Case Study Results
(Relative to Baseline)

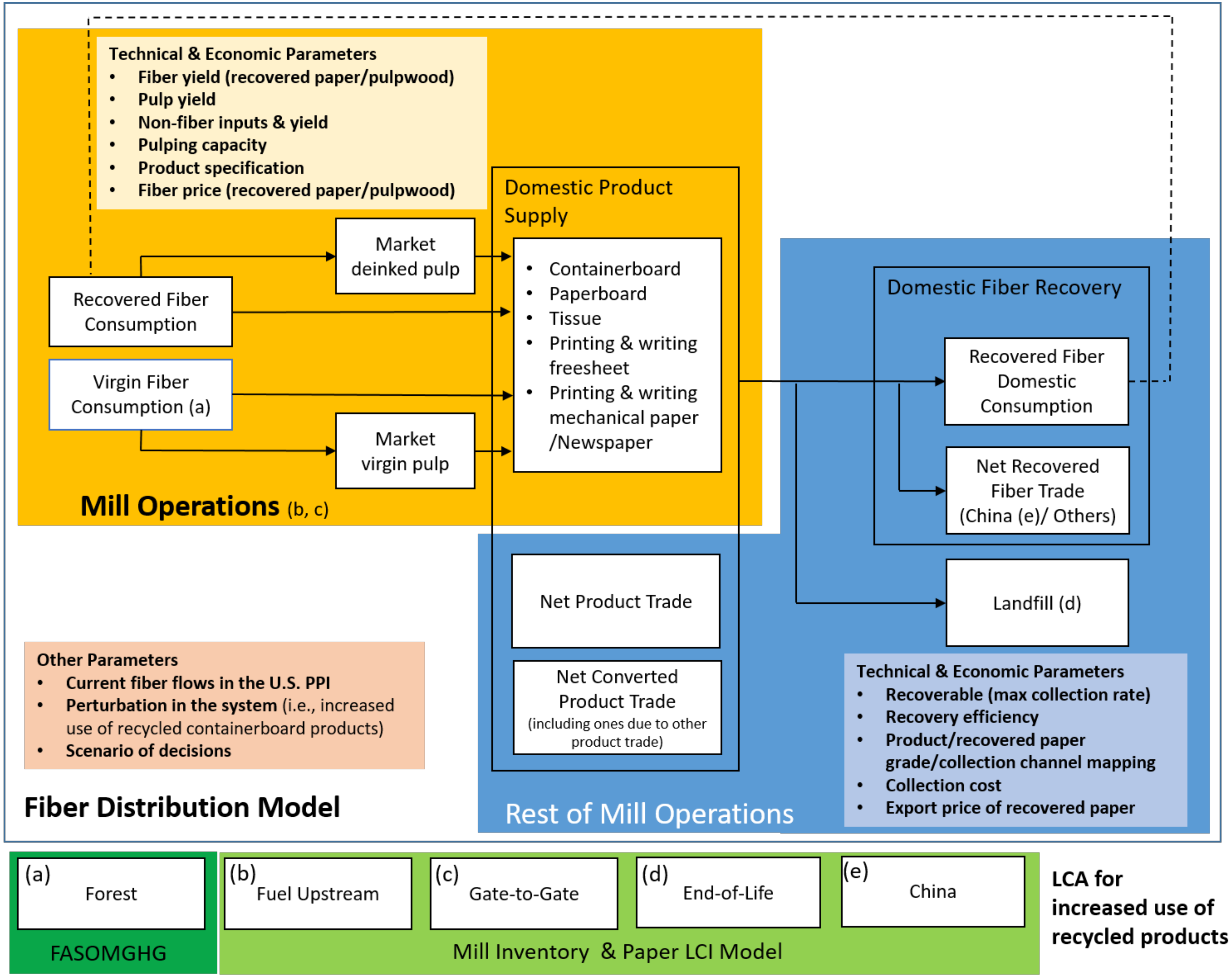
- Virgin and recycled fiber distribution change (per Sector)
- Energy Use change*
- Biogenic GHG change*
- Fossil GHG change*

* *Industry wide*

4. Case study summarizes and interprets the quantitative results compared to baseline levels

DYNAMIC FIBER FLOWS MODEL

Dynamic Fiber Flows Model Scope



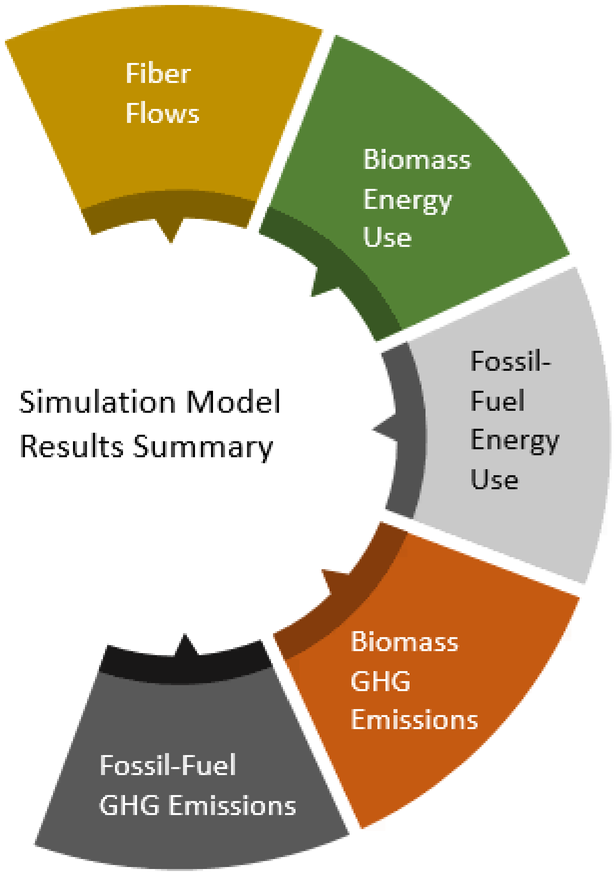
DYNAMIC FIBER FLOWS MODEL

CASE STUDIES: PRESENTING THE DYNAMIC FIBER FLOWS MODEL RESULTS

Simulation model complexity and the need to interpret quantitative output makes case studies the best way to convey the Dynamic Fiber Flows Model results

Case Study Framework

- Establish the scenario
- Summary Results
- Detailed results for fiber flows, energy use and GHG emissions
- Summarize the major take-away messages
- Indicate constraints or other information that might be considered relevant to the scenario
- Data tables



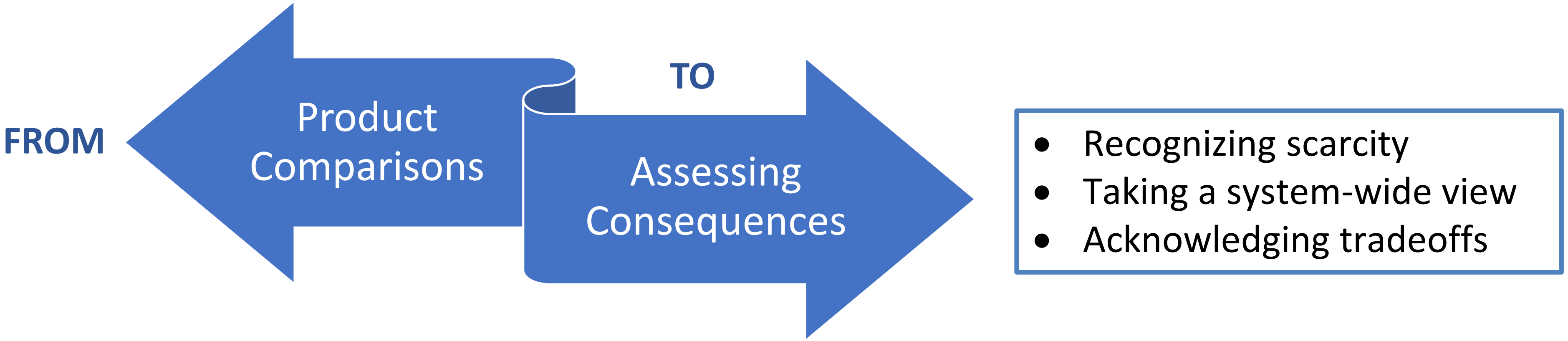
DYNAMIC FIBER FLOWS MODEL

WHY THIS MODEL IS UNIQUE

- Focus is on broad consequences on an industry-wide scale based on changes in recovered paper utilization and paper recovery, not product comparisons
- Takes a system-wide, global view across the entire paper value chain for major paper product categories
- Considers technical and economic factors, including raw material costs, fiber availability, quality, fiber yield, and processing capability.
- Identifies GHG consequences across complete product life cycle stages, from forest to end-of-life.

HOW WILL THIS MODEL BENEFIT STAKEHOLDERS?

- Case studies may be useful to better inform policymakers and corporate decision makers regarding system-wide environmental effects within their supply chains.
- Creates a new, groundbreaking approach to respond to an age-old debate



- Credibility: Published, peer reviewed MIT research, supported by the American Forest & Paper Association, the National Council for Air and Stream Improvement, the National Science Foundation, Research Triangle Institute International

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These case studies examine current and emerging real-world issues within our industry. The Dynamic Fiber Flows Model may be used to explore new questions and are designed to be updated to include future industry data and system dynamics assumptions. Please direct inquiries to info@afandpa.org