Direct Utilization of U.S. Coal as Feedstock for the Manufacture of High-Value Coal Plastic Composites

DE-FE0031809 Project Update

Monday October 19th, 2020

Create for Good.

RUSS COLLEGE OF ENGINEERING AND TECHNOLOGY

OHIO UNIVERSITY

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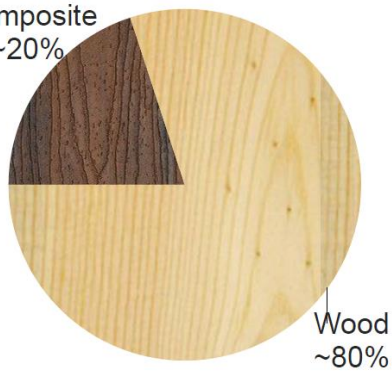
Purpose and Alignment

Purpose

- Develop coal-based composite materials for high volume construction applications
- Utilize pulverized coal or waste material from prep plant or settling ponds
- Initial Applications: Decking, railing, and framing

Composite Decking Market

- U.S. composite market currently valued at over $1 billion annually
- 12.5% AGR (2015-2020)



+1% Market Share Increase= $50M in Annual Composite Sales

Trex Investor Presentation, August 2020

Project Team and Specifics

Project Specifics

- DOE Project Manager: Anthony Zinn
- Principal Investigator: Jason Trembly
- Lead Institution: Ohio University (OHIO)
- Industry Partners: CONSOL Energy and Engineered Profiles
- Consultant: Clear Skies Consulting
- National Laboratory: Pacific Northwest National Laboratory

Period of Performance

- October 1, 2019 to September 30, 2021

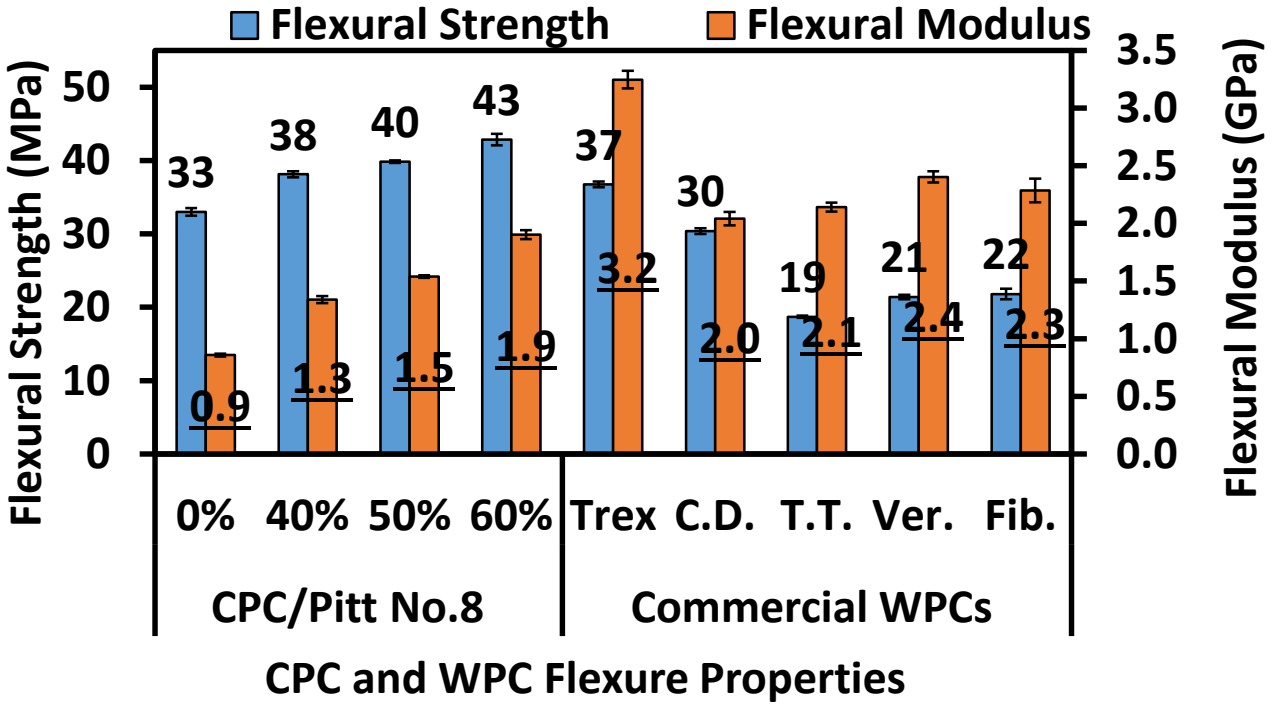
Project Budget

- Total: $2,006,578
- DOE Share: $1,500,000
- Cost Share: $506,678

Project Objectives

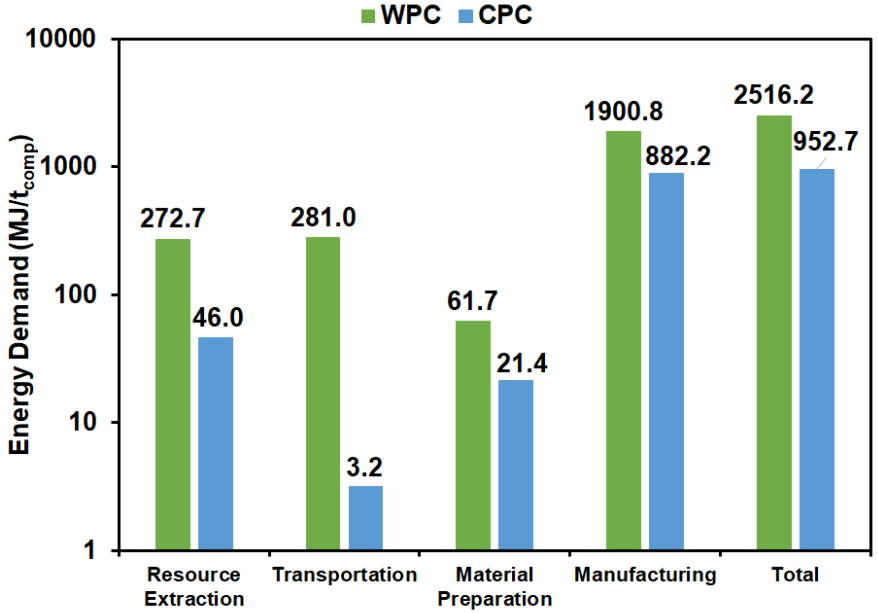
- Overall: Develop a coal plastic composite (CPC) formulation which is cost competitive and meets or exceeds ASTM and IBC specifications
- Phase 1
  - Demonstrate continuously manufactured CPC boards meet or exceed ASTM and IBC specifications for decking applications
  - Identify additional promising decking applications for CPC materials (Railings, posts, etc.)
- Phase 2
  - Demonstrate CPC board performance in the field
  - Identify CPC material installation methodologies
  - Identify additional non-decking applications for CPC formulations
  - Develop CPC marketing plan

Initial Technology Status: TRL-4

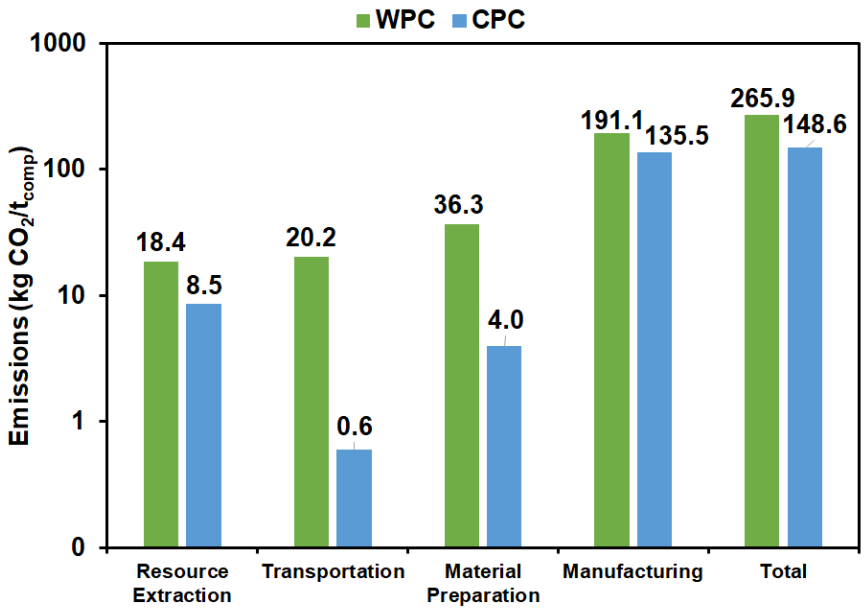


Al-Majali et al., *ACS Sustainable Chem. Eng.,* 2019, 7, 19, 16870-16878.

Initial Technology Status: LCA Results



Specific energy demand for WPC and CPC Cases.

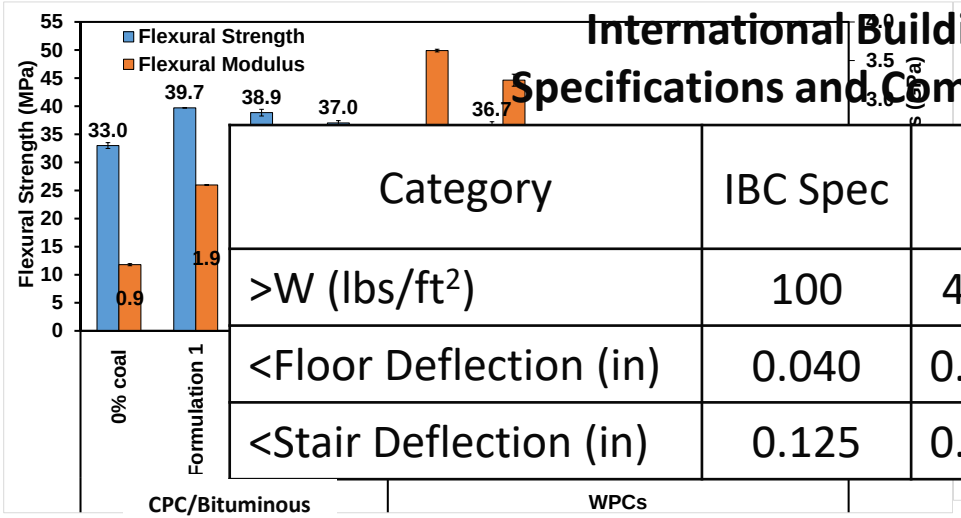


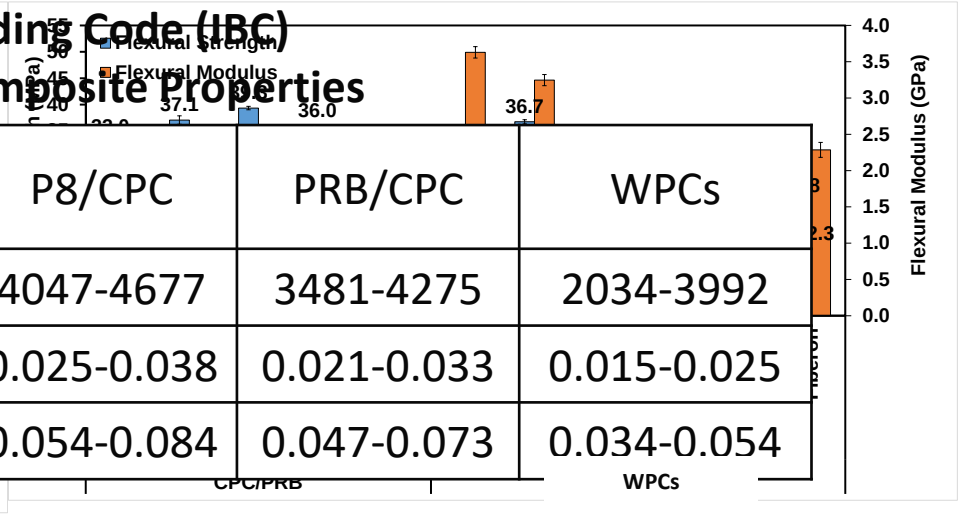
Specific emissions for WPC and CPC Cases.

- CPC materials require 62% less energy to manufacture and generate 44% less emissions than WPCs
- Including HDPE adds 4800 MJ/tonne and 280 kgCO_2/tonne

Al-Majali et al., *ACS Sustainable Chem. Eng.,* 2019, 7, 19, 16870-16878.

Current Project Status: Flexural Properties



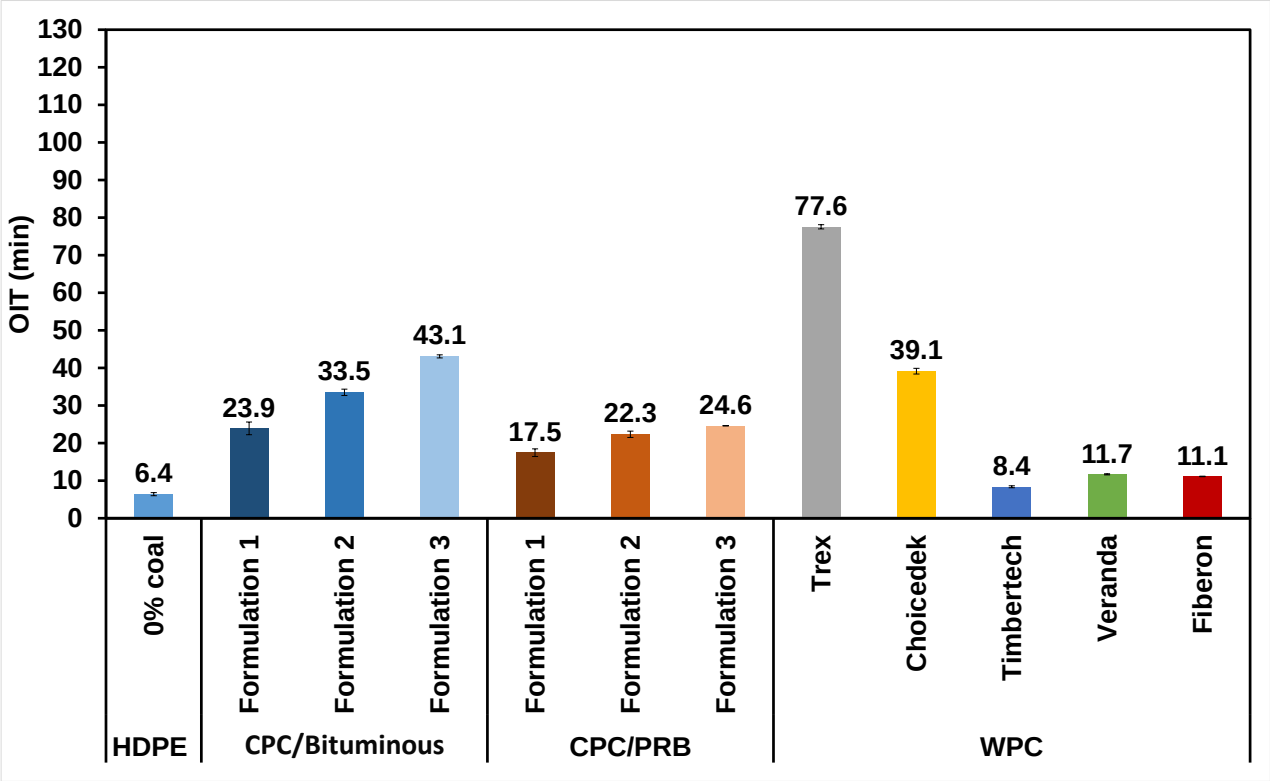


International Building Code (IBC) Specifications and Composite Properties

Category	IBC Spec	P8/CPC	PRB/CPC	WPCs
>W (lbs/ft^2)	100	4047-4677	3481-4275	2034-3992
<Floor Deflection (in)	0.040	0.025-0.038	0.021-0.033	0.015-0.025
<Stair Deflection (in)	0.125	0.054-0.084	0.047-0.073	0.034-0.054

- Test performed per ASTM D790
- Bituminous formulations possess greater strength.
- All CPC formulations meet IBC specifications for decking applications.
- CPC Safety Factors: 34-46

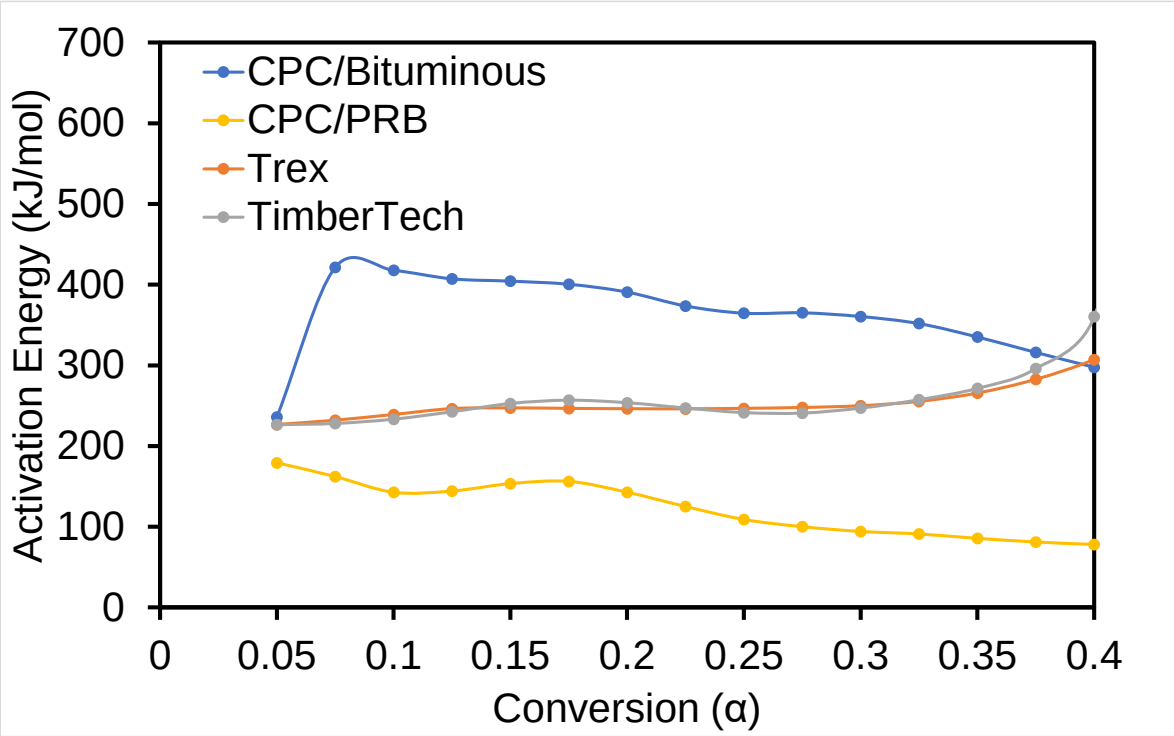
Current Project Status: Oxidation Induction Time (OIT)



- Higher OIT value indicates greater oxidation resistance.
- Determined using O_2-based isothermal DSC method.
- Bituminous formulations possess higher OIT values in comparison to PRB. formulations.
- Bituminous OIT values greater than most commercial WPCs.

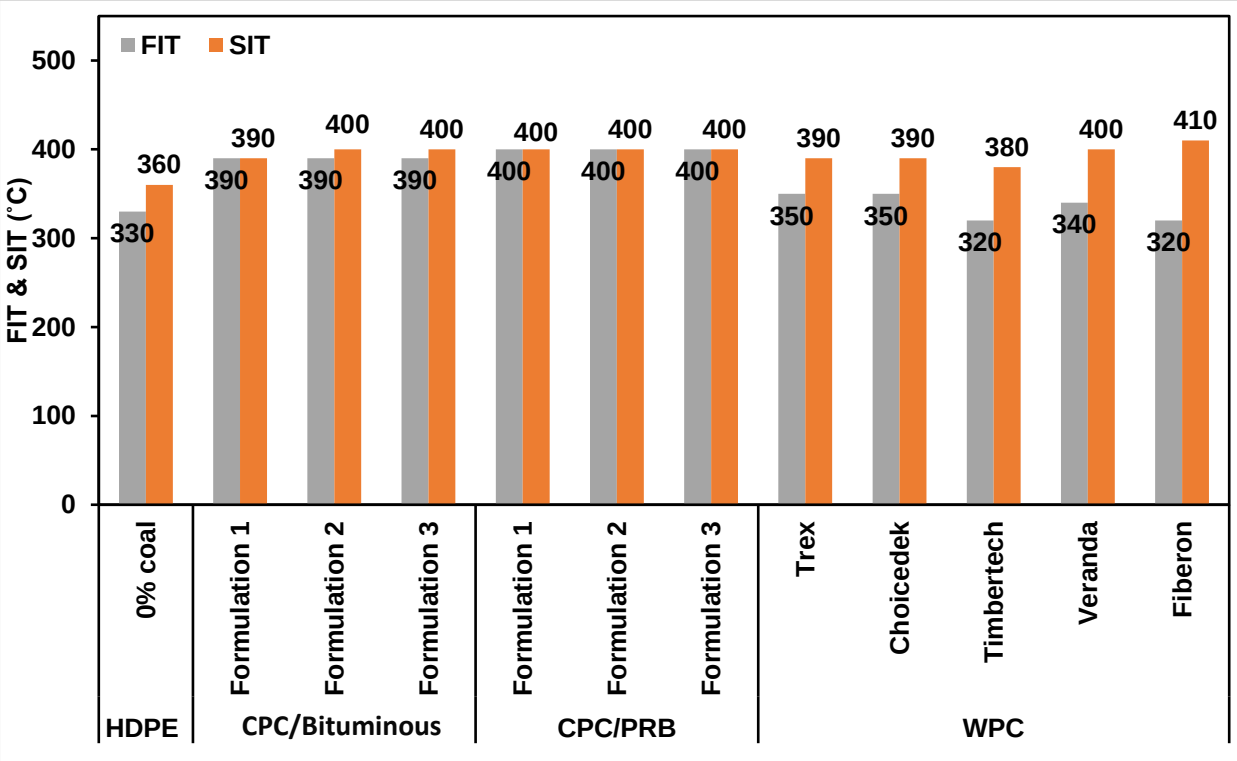
Tests performed according to ASTM D3895

Current Project Status: Oxidation Activation Energy



- Activation energy determined via isoconversional analyses in air at multiple ramp rates.
- Higher activation energy indicates more stable material.
- Results indicate bituminous CPC formulations should have longer product life than WPCs.
- PRB CPC formulations more susceptible to oxidation.

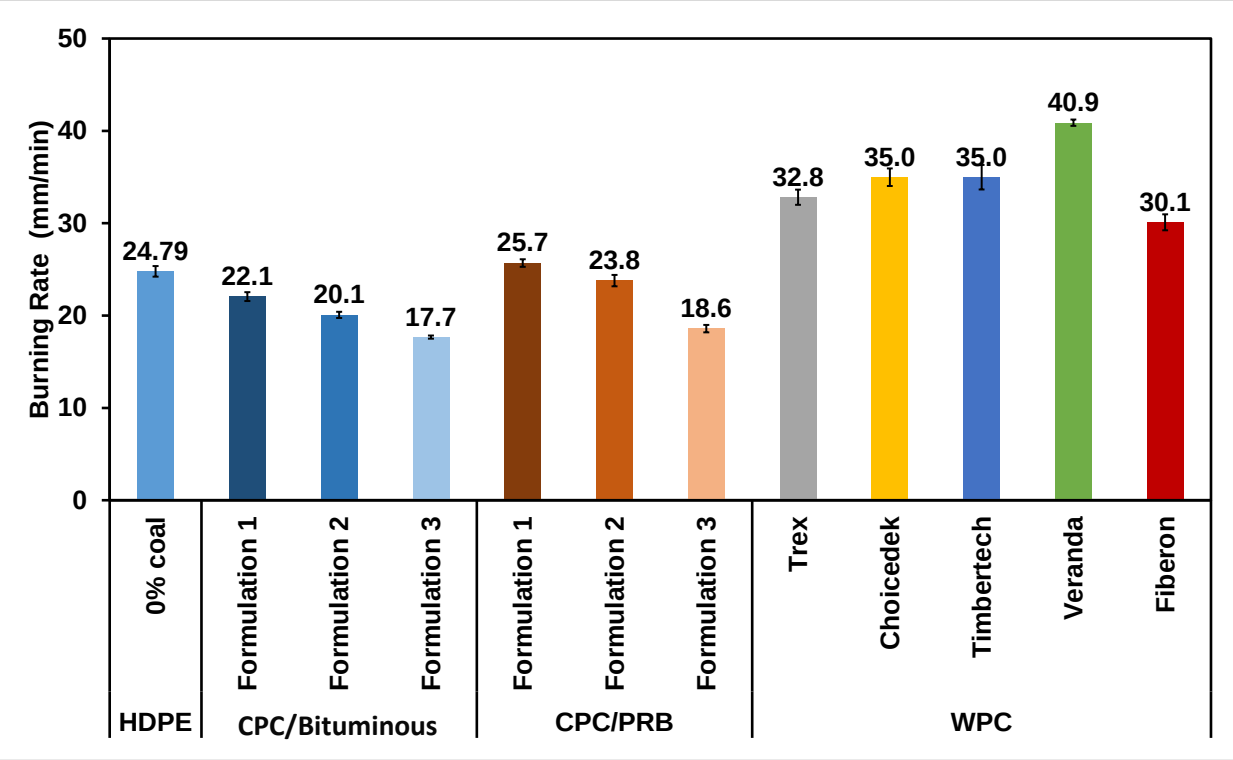
Current Project Status: Flash/Self Ignition Temperatures (FIT/SIT)



- FIT: Temperature at which volatiles ignite with external flame.
- SIT: Temperature at which material ignites in absence of flame.
- CPC formulations possess higher FIT values than WPCs.
- SIT values similar for CPCs and WPCs.

Tests performed according to ASTM D1299

Current Project Status: Rate of Burning (RoB)

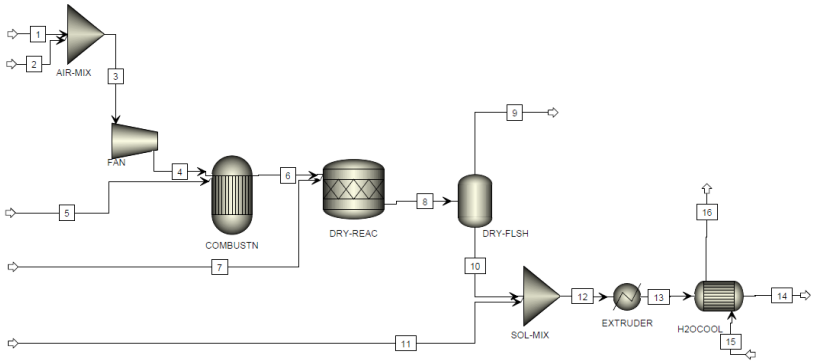


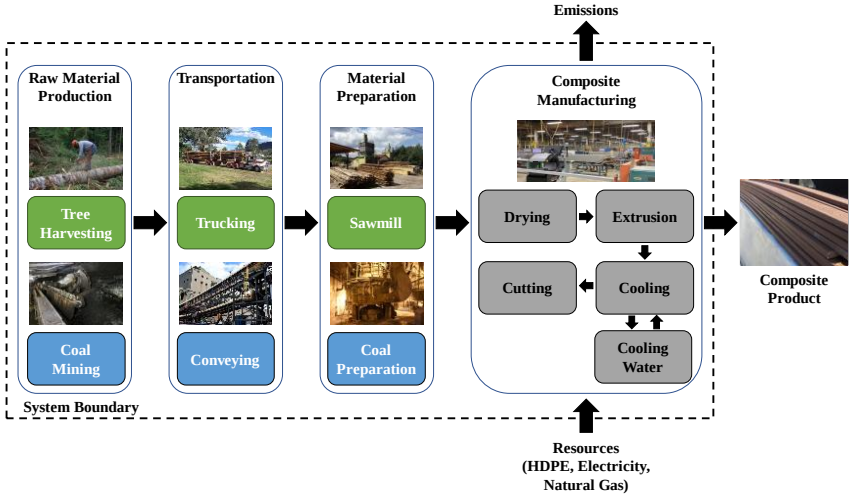
- Comparable to ASTM E84 for composite boards.
- Lower RoB value indicates less flammable material.
- CPC formulations possess significantly lower RoBs than WPC.
- Bituminous formulation RoBs slightly lower than PRB formulations.

Tests performed according to ASTM D635

Current Project Status: TEA/LCA

- Process simulations developed to accurately assess material/energy balances for a commercial manufacturing facility.
- Sensitivity analyses underway:
  - Capacity, feedstock pricing, formulation, operating costs, etc.
- Analyses to date indicate 25-40% reduction in operating costs in comparison to WPC manufacturing.
- Projected manufacturing energy and GHG emissions reductions.

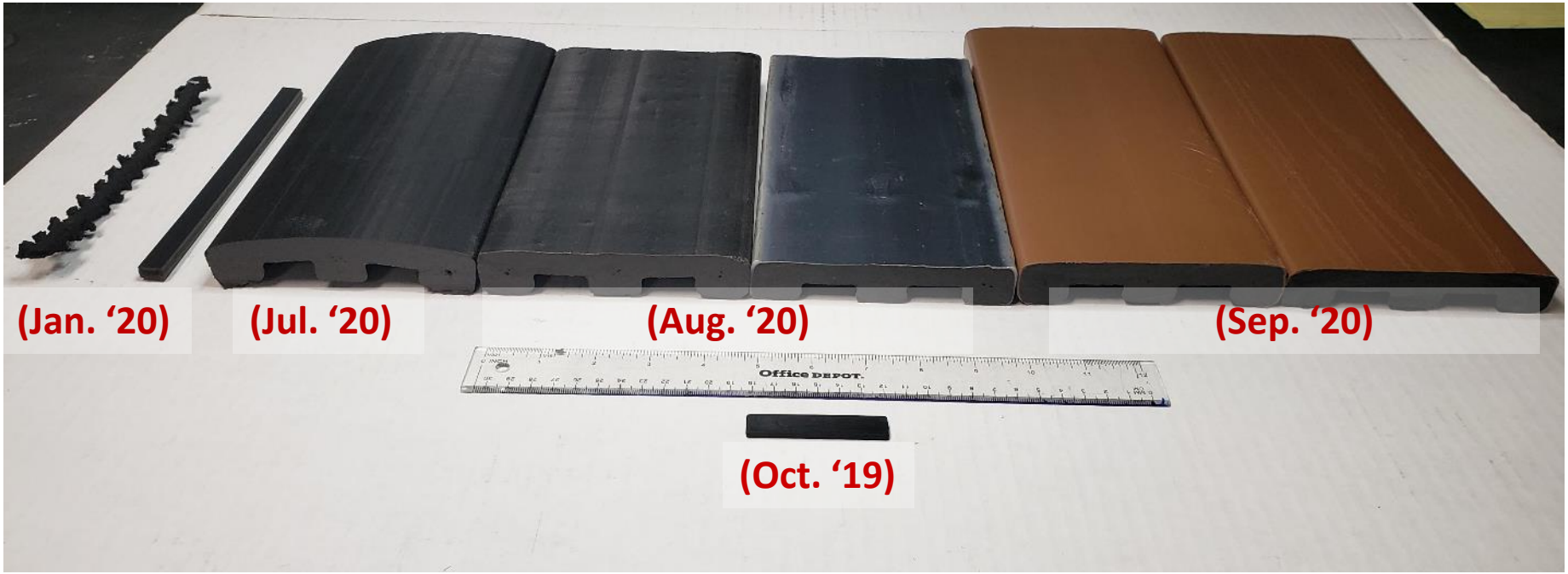




Current Project Status: Continuous CPC Manufacturing

- Continuous manufacturing underway at Engineered Profiles (Columbus, OH).
- Materials mixing system procured and installed.
- Extrusion tooling developed and installed on commercial extrusion line.
- Formulation development initiated in January with board manufacturing trials beginning in July.

Current Project Status: Board Development Timeline



Market Benefits & Path Forward

Market Benefits

- Lower or equivalent priced product with better properties.
- Utilizes pulverized coal or mining waste materials.
- Easily translatable manufacturing methodologies.

Technology-to-Market Path

- Results from project will provide blueprint to design, build, and operate a commercial CPC manufacturing facility.
- Additional market applications and new research areas have been identified.

Next Steps

- Complete ASTM D7032 testing with CPC boards.
  - If necessary, refine CPC formulations.
- Continuously manufacture CPC boards for use in full-size decks.
- Perform marketing study.
- Perform environmental and occupational health studies.
- Develop and execute scale-up and commercialization plan.

Concluding Remarks

- Analyses indicate CPC formulations have equivalent or superior properties in comparison to WPCs for decking applications.
- TEA and LCA studies indicate attractive manufacturing cost savings and energy/emissions reductions compared to WPCs.
- CPC manufacturing has been successfully scaled to a commercial WPC manufacturing line.

Acknowledgements

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