

U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

BETO Wood Heat Financial Assistance

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Feedstock



Algae



Conversion



Systems



Data



Brookhaven
National Laboratory



BERKELEY LAB

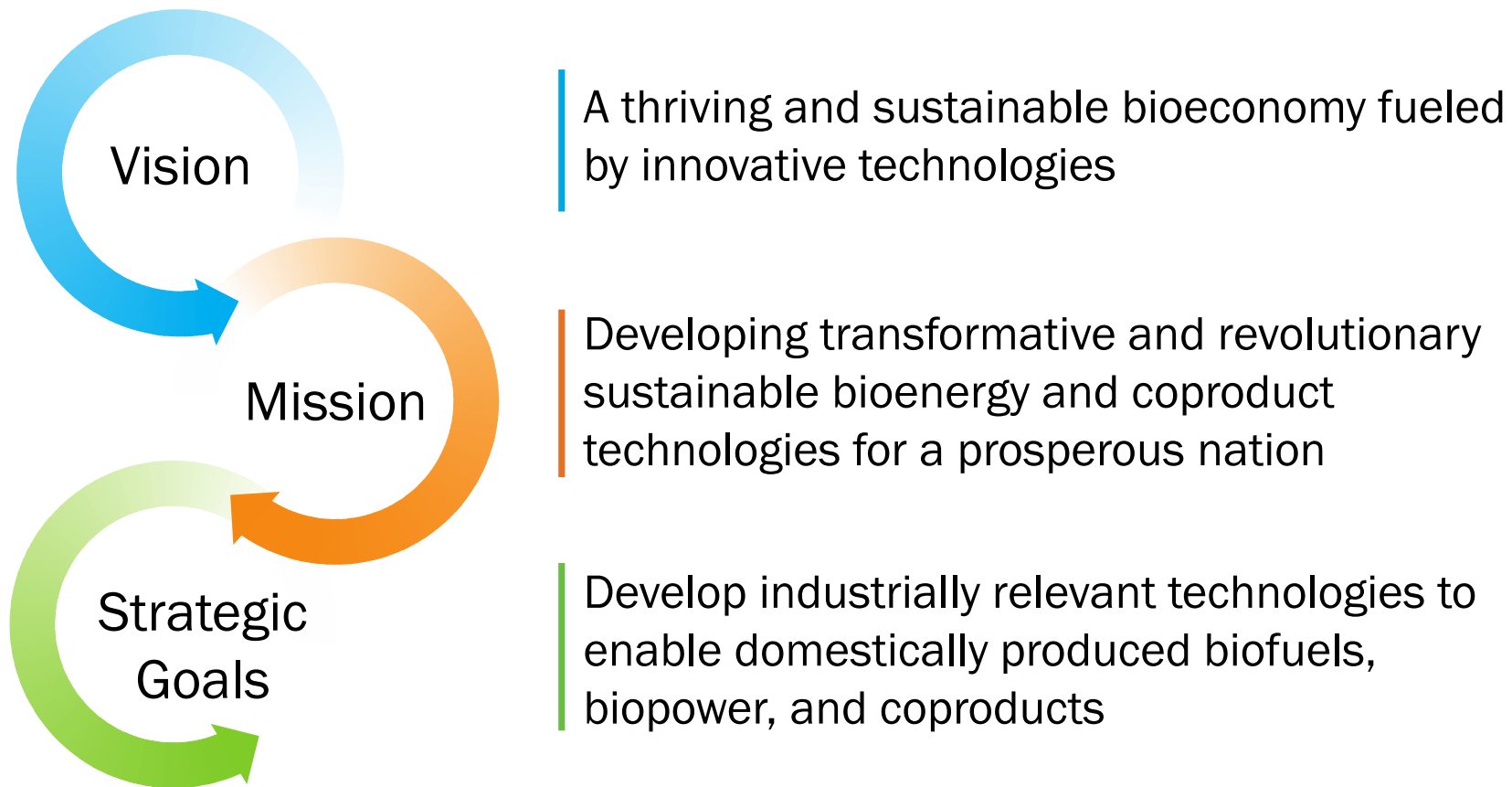




I. Bioenergy Technologies Office Overview

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BETO Mission, Vision, and Strategic Goals



Feedstock
Technologies



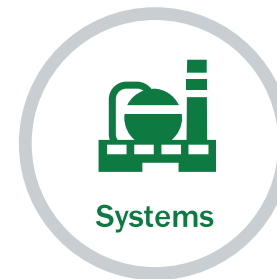
Advanced
Algal Systems



Conversion
Technologies



Systems
Development
and Integration

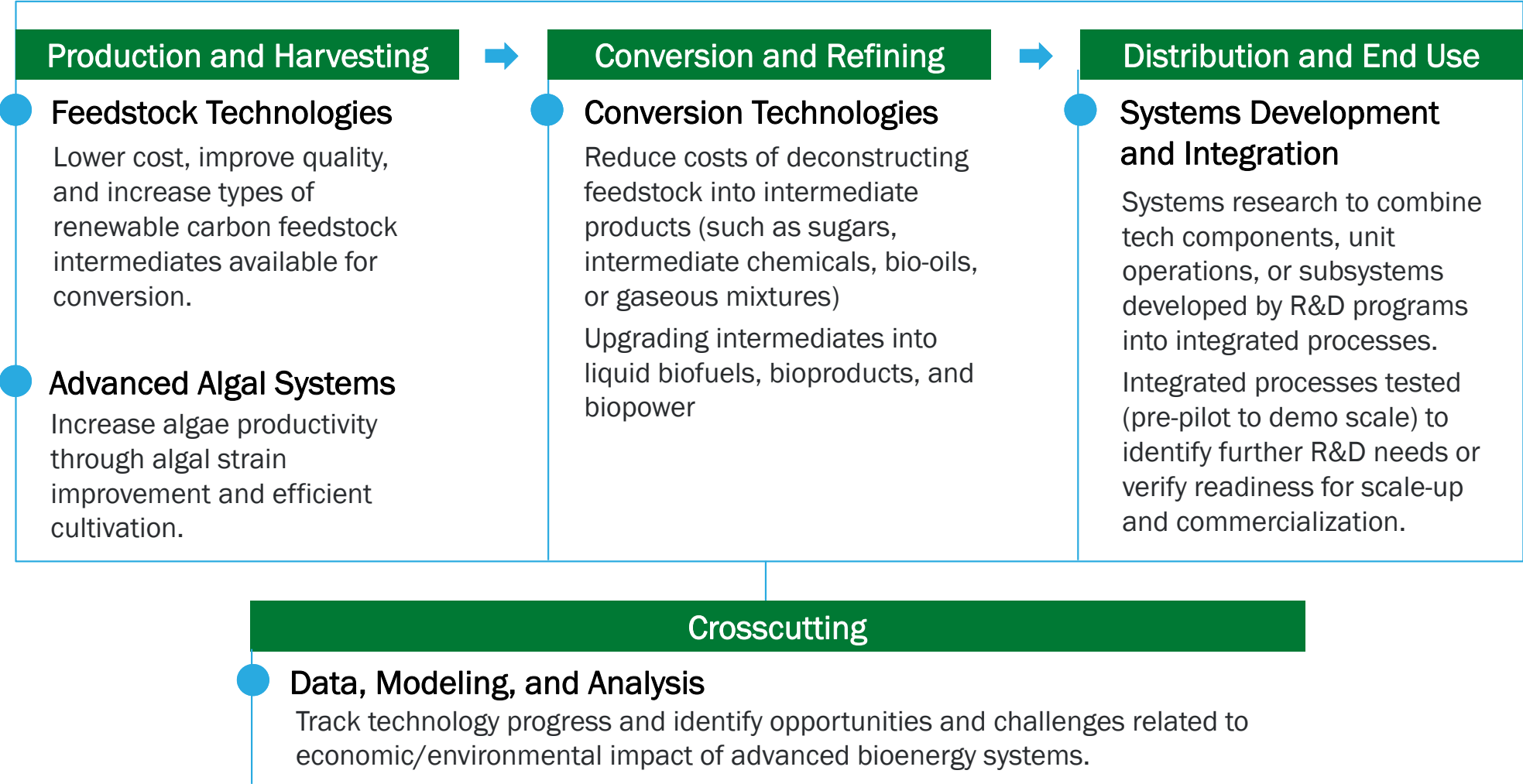


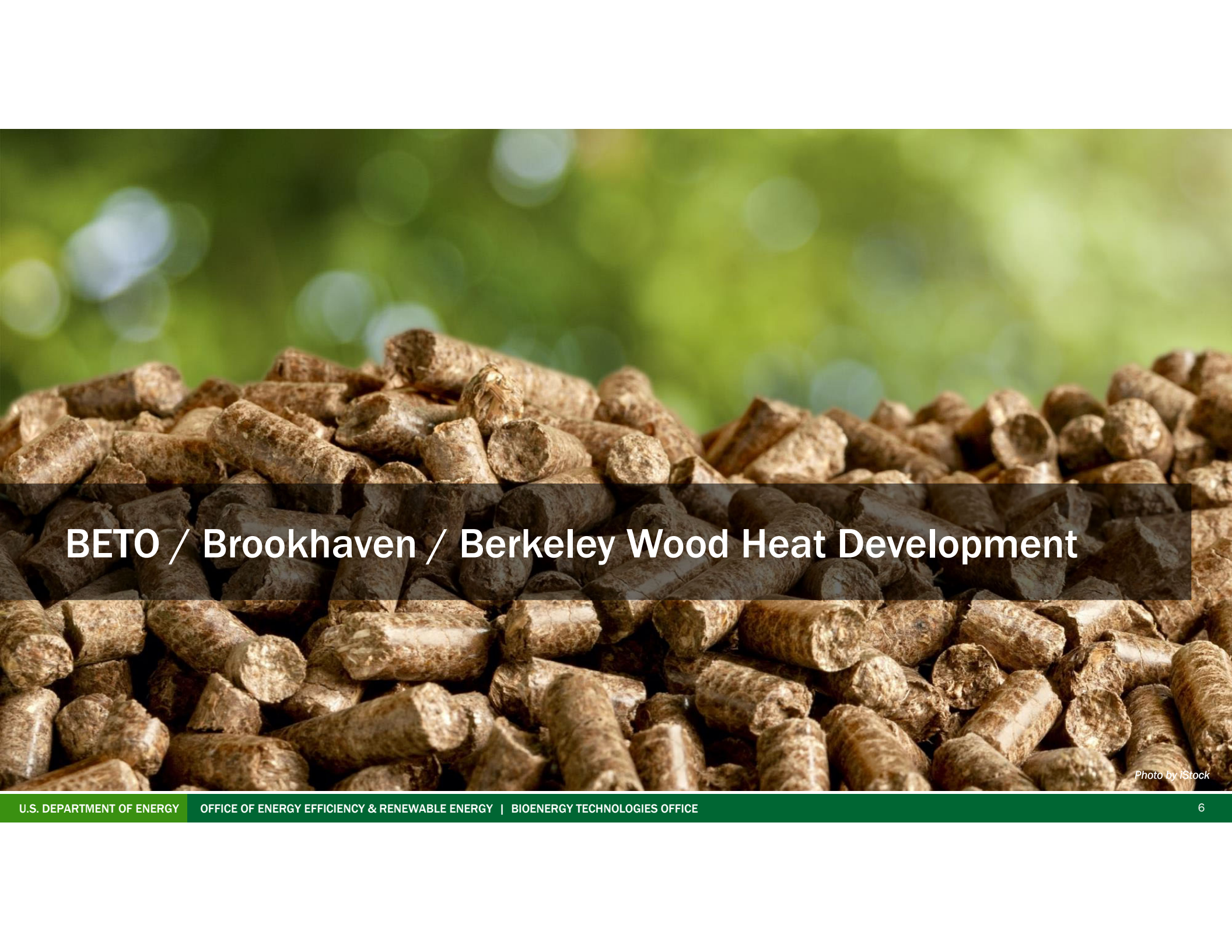
Data, Modeling,
and Analysis



Bioenergy
Technologies Office
Program Areas

BETO Critical Program Areas





BETO / Brookhaven / Berkeley Wood Heat Development

Photo by iStock

Biomass: A renewable fuel

- 2.4 million US homes use wood as primary heat source
- In 2020, largest percentage of renewable energy consumed by the residential and commercial sector was supplied by wood and waste (not including liquid fuels produced from biomass feedstocks), followed by solar at 54% and 38%
- States have recognized wood-fired appliances will play a significant role in the future of their heating sector
 - Vermont's Comprehensive Energy Plan (CEP) plans to get 35% of their thermal energy from wood
- In Austria, around 55% of renewable energy is from biomass
 - 50% of district heating is produced from biomass

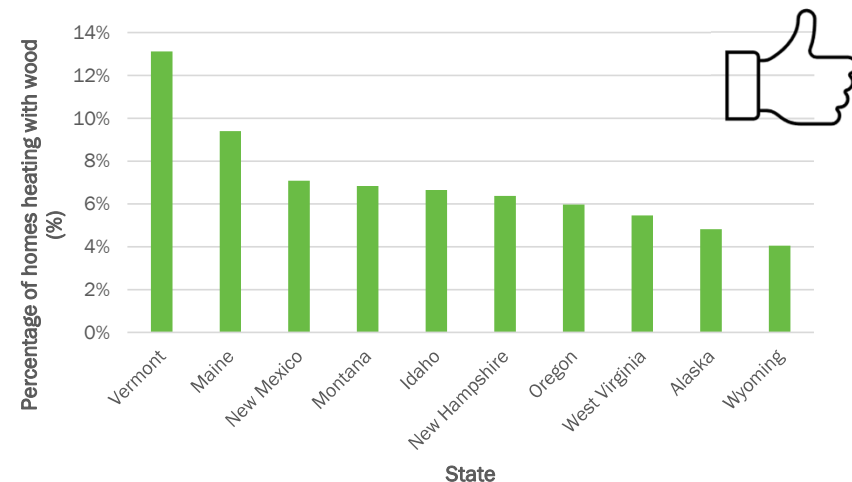
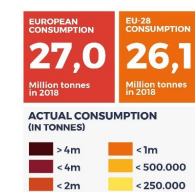


Figure 5: States with the highest percentage of homes heating with wood (data taken from 2019 ACS (United States Census Bureau, 2019))

EUROPEAN / EU-28 WOOD PELLET CONSUMPTION

(IN 2018, TONNES, %) SOURCE: EPC SURVEY 2019, HAWKINS WRIGHT



EU-28 consumption increased by 8,0% between 2017 and 2018.

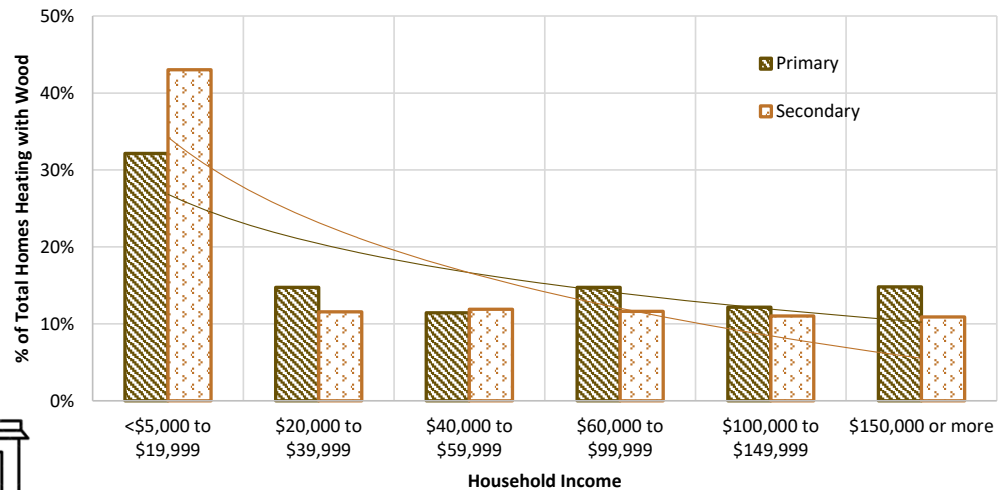
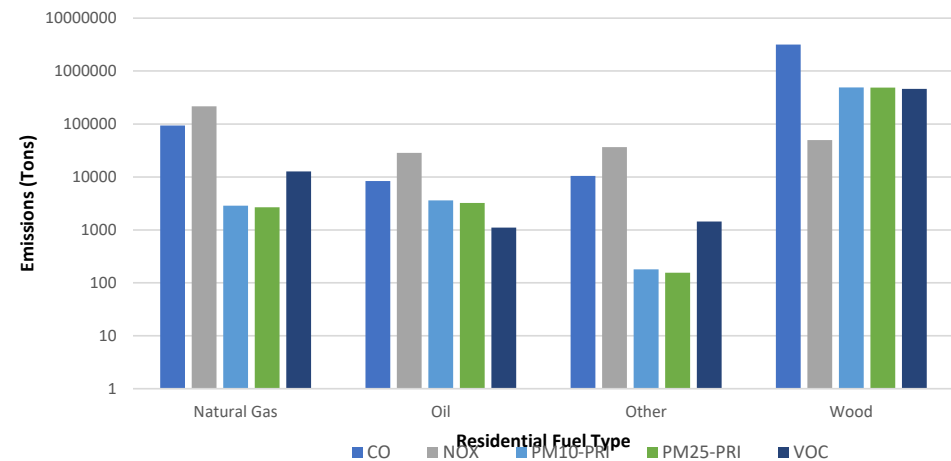
CONSUMPTION IN TOP 5 EU-28 COUNTRIES IN 2018



<https://epc.bioenergyeurope.org/about-pellets/pellets-statistics/european-consumption/>

Emissions from Residential Wood Heat

- States and countries have recognized wood-fired appliances will play a significant role in the future of their heating sector ^{1,2}
- For many who aren't on municipal gas lines, choosing an alternative heat source like wood, oil or propane is a necessity
- In 2020, largest percentage of direct renewable energy consumed by the residential and commercial sector was supplied by wood and waste at 54% (not including liquid fuels produced from biomass feedstocks), followed by solar at 38% ³
- Direct combustion of biomass in homes is the most common use of woody feedstocks but is the **dominant factor in ambient air quality** in many parts of the US
 - ~6% of US total annual PM_{2.5} emissions are from wood heaters ⁴
 - >57% of the health-related social costs attributed to air pollution from the residential heating sector ⁴
- 2.3 million US homes use wood as a primary heat source ⁵
- As many as 30 million US residents are impacted by woodsmoke each year ^{6,7}
- Biomass emissions in NYC alone caused 0.707 – 1.55K deaths (\$8.12 – 17.8 billion USD) in 2017 ⁸



¹ Agency of Natural Resources- Forests, Parks & Recreation Vermont. (n.d.). Wood Energy. Retrieved from <https://fpr.vermont.gov/forest/wood-energy>

² Kranzl, L., Kalt, G., Muller, A., Hummel, M., Egger, C., Ohlinger, C., & Dell, G. (2013). Renewable energy in the heating sector in Austria with particular reference to the region of Upper Austria. *Energy Policy*, 17-31.

³ US Energy Information Administration (EIA). (2020). U.S. renewable energy consumption by source and sector, 2020. Retrieved from https://www.eia.gov/energyexplained/renewable-sources/images/renewable_energy_2020.pdf

⁴ <https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data#datas>

⁵ U.S. Energy Information Administration, 2020 Residential Energy Consumption Survey (RECS) Data, 2020.

⁶ Noonan, C. W. (2015). Estimating the Number of Vulnerable People in the United States Exposed to Residential Wood Smoke. *Environmental Health Perspectives*, A30-A31.

⁷ Rogalsky, D. K., Mendola, P., Metts, T. A., & Martin II, W. J. (2014). Estimating the Number of Low-Income Americans Exposed to Household Air Pollution from Burning Solid Fuels. *Environmental Health Perspectives*, 806-810.

⁸ P. Salimifard, J. J. Buonocore, K. Korschnik, P. Azimi, M. VanRy, J. Guillermo Cedenio Laurent, D. Hernández and J. G. Allen, "Climate policy impacts on building energy use, emissions, and health: New York City local law 97," *Energy*, vol. 238, 2022.

Fig. 1 Adapted from <https://www.epa.gov/air-emissions-inventories/2020-national-emissions-inventory-nei-data#datas>

Fig. 2 Adapted from <https://www.eia.gov/consumption/residential/data/2020/>

Wood Heater Funding Opportunities

FY23 Appropriations Bill

- The agreement provides up to \$5,000,000 for continued support of the development and testing of new domestic manufactured low-emission, high-efficiency, residential wood heaters that supply easily accessed and affordable renewable energy and have the potential to reduce the national costs associated with thermal energy.

Prior Successes

- Funding via competitive funding opportunity announcements (FOA) and wood heater technology development at national laboratories.
 - 3 FOA's F19 – FY21
 - Technology development at Brookhaven National Lab and Lawrence Berkeley National Lab
 - 5th Wood Heater Design Challenge
 - FY22 Workshop Series

Wood Heater Innovation Collaboration CRADA Call Announced June 1, 2023

DE-FOA-0002029 Selections

- **MF Fire - Swirl Stove: Swirling combustion for efficient wood burning**

- Swirling combustion is used for mixing combustion air with fuel gasification products to achieve a more complete burn, thereby reducing emissions and increasing efficiency.



- **ISB Marketing – Automated Wood Stove**

- Develop a self-regulating wood stove using Machine Learning to automatically adjust combustion parameters.



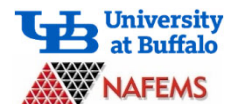
- **MF Fire – Fire MAPS: Secure Performance Monitoring and User Alerts System**

- Software & sensors to monitor performance of key combustion indicators in the wood stove and deliver real-time user guidance and burn status to the user.



DE-FOA-0002203 Selections

- **NTRE Tech - Advanced Low-Emission Residential Fluid Bed Biomass Combustor**
 - Design, construct and test a low-emission and efficient residential wood-fired central heater based on the novel application of fluidized-bed technology.
- **Ohio State University - Flow Path Automation and Model-Based Design for Cordwood-Fueled Room Heaters**
 - Develop and experimentally validate a virtual machine replica of both catalytic and non-catalytic wood heaters. The project team includes The University at Buffalo, Oak Ridge National Laboratory, The New Buck Corporation, and NAFEMS America .



DE-FOA-0002396 Selections

- **The University of Alabama – Clean Combustion Technology with Efficient and Autonomous Wood Heater Operation Over the Full Cycle**
 - Develop a modern non-catalytic wood heater for residential applications utilizing wood chips, cord wood, and wood pellets.
- **Oregon State University - Development of Forced-Air Combustion Systems with Automated Controls to Reduce Emissions for Cordwood Room Heaters in Everyday Use**
 - Undertake the development needed to reduce PM emissions throughout the real-world burn cycle of cordwood room heaters by incorporating turbulent jets of forced air into the firebox. .



FY23 Wood Heater Innovation Collaboration CRADA Call

A Cooperative Research and Development Agreement (CRADA) is any formal written agreement between one or more Federal laboratories and one or more non-Federal parties under which the government, through its laboratories, provides personnel, services, facilities, equipment, intellectual property, or other resources. <https://www.doi.gov/techtransfer/crada>

Wood Heater Innovation Collaboration CRADA Call

- Brookhaven National Laboratory (BNL) and Lawrence Berkeley National Laboratory (LBNL), funded by the DOE Bioenergy Technologies Office (BETO), will oversee a Cooperative Research and Development Agreement (CRADA) to **accelerate wood heater innovation and develop the next generation of efficient and clean wood heaters**.
- No less than **\$4 million** will be available for this CRADA call and **up to six projects per phase** will be selected with a **project duration of 12 to 18 months**.
- Intended for industry and universities interested in leveraging the Wood Heater Innovation Collaboration (WHIC) capabilities to support the advancement of residential wood heating technologies.
- Simpler proposal process / agile funding opportunity



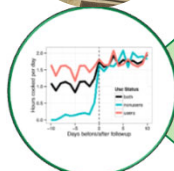
What we offer



Novel technology development and validation



Laboratory testing for R&D



Data analysis to inform R&D



Monitoring, sensors, and automation development



Field testing and evaluation



Quantifying user behavior and community education

Capabilities

Experienced teams with state-of-the-art facilities and resources:

- Real-time gaseous and particle emissions
- Thermal Performance
- Computational modeling and validation
- And more...



Berkeley Lab Facility
stoves.lbl.gov

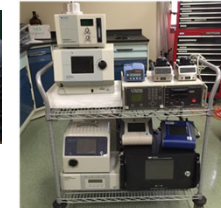
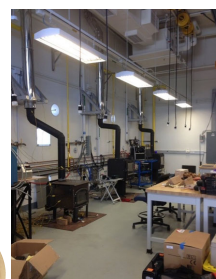
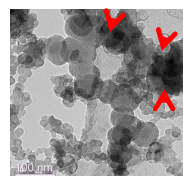


Brookhaven Lab Facility
bnl.gov/isd/conversion





- Development of Partial Thermal Storage Method
- Evaluation of fuel quality impact and burn phase
 - Recommendations for mitigating high-emission periods
- Testing of technologies and prototypes in the laboratory and field
 - Real-time measurement methods
 - Detailed emission characterization with use of microscopy
 - Wood Stove Design Challenges!
- Expertise in developing low-emission technologies
 - Ability to model fluid flows within combustion chamber for faster integration of designs
 - Successful collaboration with others on the development of biomass heaters through strategy, prototyping and



www.bnl.gov/isd/conversion.php



- **Advance biomass technologies for next-generation systems**
 - Technology development and performance evaluation
 - Experimental analysis for optimizing biomass systems
- **Develop harmonized performance protocols**
 - Translate standard protocols from lab to field
 - Identify critical equipment and performance metrics and for field testing
- **Fundamental research of biomass systems**
 - Expertise in emissions and impact on health and indoor/outdoor air quality
 - Computational modeling for optimization
 - Expertise in combustion science



stoves.lbl.gov



Example Activities

- Advancing automation systems
- Sensor development for remote data collection
- Analyzing and synthesizing field and laboratory data
- Investigating feasibility of novel pre and post combustion technologies to reduce emissions or improve efficiency
- Developing computational models to inform engineering design improvements
- Investigating feasibility of integrating wood heaters with other technologies to reduce emissions and increase efficiency
- Identifying and implementing advanced combustion methods or technologies to reduce emissions during various phases of operation
- Developing alternative test methods for certifying wood heaters that cannot be tested using EPA certification methods

Activities not considered

- Certification testing of wood heaters
- Testing and advancing technologies not related to wood heaters
- Dual-fuel technologies that integrate wood heaters with pipeline natural gas, propane resources, e.g. or appliances





**Wood Heater
Innovation Collaboration**

Learn more about WHIC CRADA: <https://woodheat.bnl.lbl.gov/>
Or Email: woodheat@lbl.gov

Learn more about BETO: energy.gov/bioenergy



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BERKELEY LAB

