# Welcome to the Webinar- NETL RWFI Energy 101

Learn about NETL's research and capabilities around **microwave energy technologies** and workforce implications breakthroughs in microwave energy technologies may have for the region and the country in this edition of the NETL RWFI Energy 101 Series.

**WEBINAR IS RECORDED**

**Agenda**

- NETL Regional workforce Initiative Updates – Anthony Armaly, NETL RWFI Federal Lead
- Energy 101- Microwave Energy Technology – Christina Wildfire, NETL Research Scientist
- Energy 101 RWFI Q&A Session
- Pleases Mute, Slides and recording will be available some time after the presentation.
- Questions Thru the chat function

# NETL Regional Workforce Initiative (NETL RWFI)

NATIONAL ENERGY TECHNOLOGY LABORATORY

A Focus on Appalachia and the future of Energy and Advanced Manufacturing Regional Workforce Readiness and Economic Development

U.S. DEPARTMENT OF ENERGY

# NETL RWFI Mission Statement

NETL RWFI is a platform for engagement and collaboration with key stakeholders who are critical for the deployment of U.S. DOE and NETL Energy and Advanced Manufacturing technological research.

Supporting Regional Economic and Workforce Development opportunities.

# NETL RWFI- Measuring Our Impact - People First

Key Metrics are Levels of Engagement and Outreach

**800+**
individual stakeholders

**400+**
institutions and organizations represented

**2000+**
registrants to the NETL RWFI Webinar Series

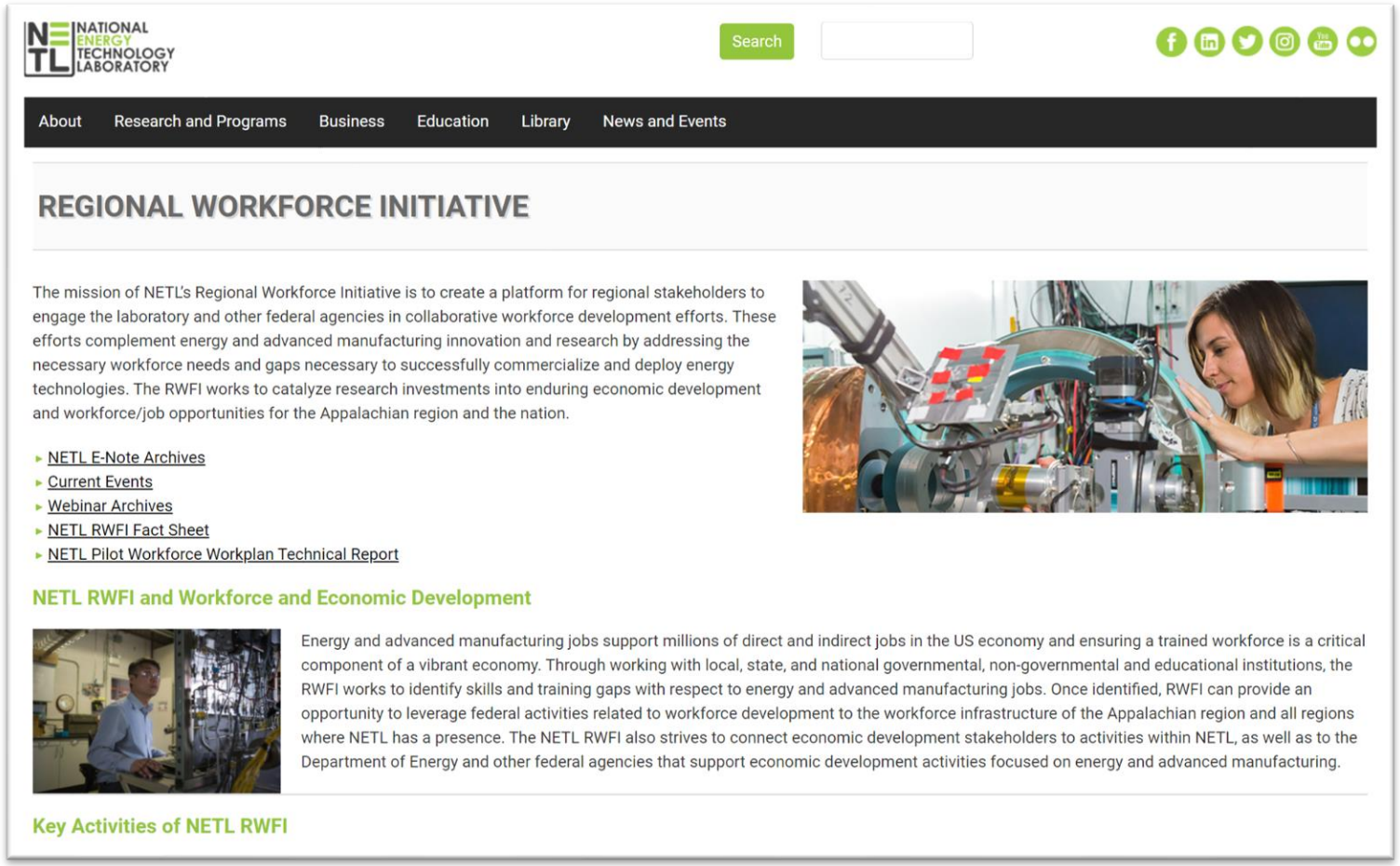
**300+**
subscribed to the NETL RWFI e-Note Monthly Newsletter

**Catalyzed over 1M in energy/advanced manufacturing workforce & economic development funding**

# Consistent Engagement & Output

Outreach Tools

- Webinars  (Energy 101 Series)
- Networking (meetings, lab tours, site visits)
- E-note (monthly) Webinars Archive
- RWFI website and archives
- [www.netl.doe/gov/rwfi](www.netl.doe/gov/rwfi)



# Regional in Focus, National in Reach

400+ Organizations Representing Multiple Stakeholder Groups

NATIONAL ENERGY TECHNOLOGY LABORATORY

**Stakeholder groups include:**

- Economic Development Organizations
- Federal, State, & Local Governments
- Community Colleges & Universities
- Philanthropic Organizations
- National Laboratories
- Workforce & Other NGOs
- Industry

Appalachian Regional Commission
America Makes
Belmont College
TEAM Consortium
Benedum Foundation
BRITE Energy Innovators
Catalyst Connection
Carnegie Mellon University
Claude Worthington Benedum Foundation
Energy Futures Initiative
National Association of Workforce Boards
Coalfield Development Corporation
Community College of Allegheny College
Westmoreland Community College
PA Department of Economic Development
University of Pittsburgh
Siemens Corporation
Eastern Community College West Virginia
E2 Network
IACMI
ARM consortium
IN-2-Market, Inc.
Manufacturing Extension Partnership
West Virginia University
WVU Industrial Extension/MEP
Allegheny Conference
Charleston Area Alliance
Electric Power Research Initiative
Pittsburgh Regional Alliance
Robert C. Byrd Institute
Oak Ridge National Laboratories
West Virginia University

# Latest RWFI Collaborative Efforts

- **Industrial Efficiency Training:** IEDO (NREL & Oak Ridge)
- **Workforce Skills Projections:** NREL & Julius Education. Projecting Fossil Energy skills to EERE skills overlap
- **Training/University Engagement:** Univ. of Pittsburgh Applied Data Driven Methods Grad. Certificate Program (ADDM)
- **Other National Laboratory Engagement:** 2023 TCF- MSI Connect Program with Brookhaven National Lab to improve MSI engagement with labs

# U-Pitt Collaboration- Funding from ARC, BBB, and DOL – Tuition Reimbursement- Data Skills

Appalachian Regional Commission and Benedum Foundation

*ELIGIBILITY*

- *Residents of Fayette and Westmoreland Counties*
- *Those with demonstrated financial need*

Build Back Better Regional Challenge

*ELIGIBILITY*

- *Residents of Armstrong, Allegheny, Beaver, Butler, Fayette, Greene, Indiana, Lawrence, Washington, and Westmoreland Counties*
- *Unemployed, underemployed, or dislocated workers*

Department of Labor Workforce for Rural Communities

*ELIGIBILITY*

- *Residents of Beaver, Fayette, Greene, Washington, and Westmoreland Counties*
- *Dislocated workers*

**Skills training, and Re-employment**

- Tuition coverage for students within the region and underemployed (covid and Energy Transitions Impact)
- Unemployed, underemployed, dislocated workers
- Regional preference

**NETL RWFI**

- Provided awareness of the funding opportunity through BBB and DOL WORC work grant
- Provided letter of support for ARC proposal
- Collaborating on professional development of students

**U-Pitt and NETL RWFI future collaborative efforts**

- Working with Pitt on J40 and energy justice impacts measurements
- NSF engines grant with regional group (pending selection)
- Career day with regional industry for students

# Contact Information

NATIONAL ENERGY TECHNOLOGY LABORATORY





*For More Information, Contact Anthony Armaly*

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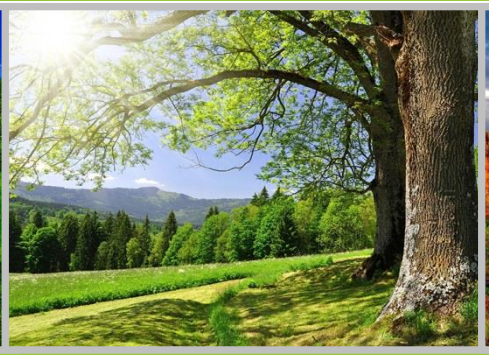
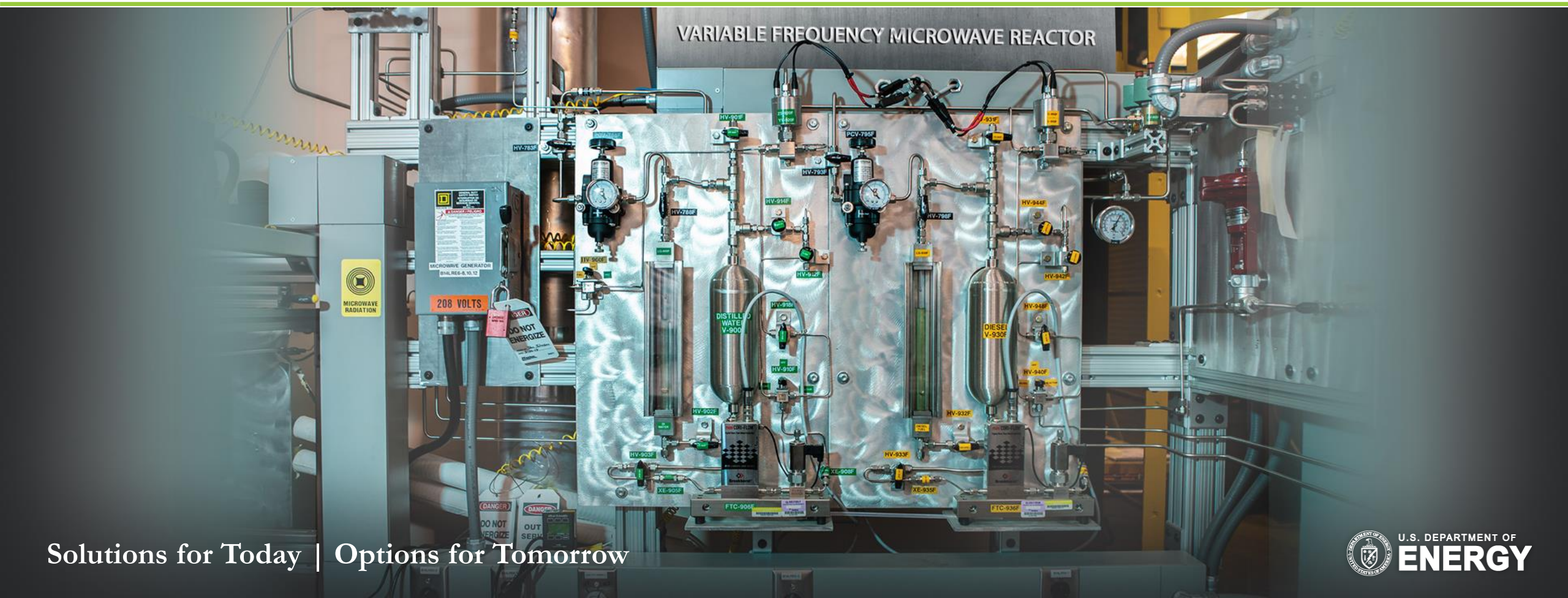


# Microwave Technology

## Process Innovations to Drive Advantage

Christina Wildfire, Ph.D., Reaction Engineering Team



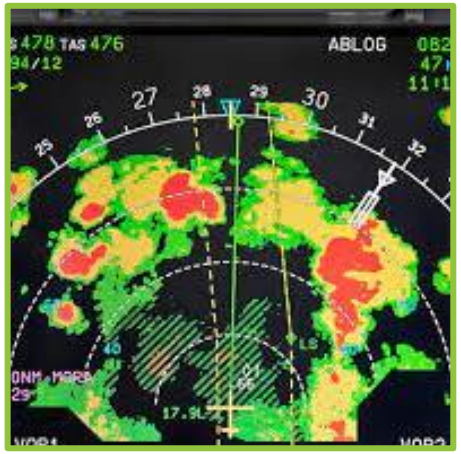

Solutions for Today | Options for Tomorrow

# Microwave Technology

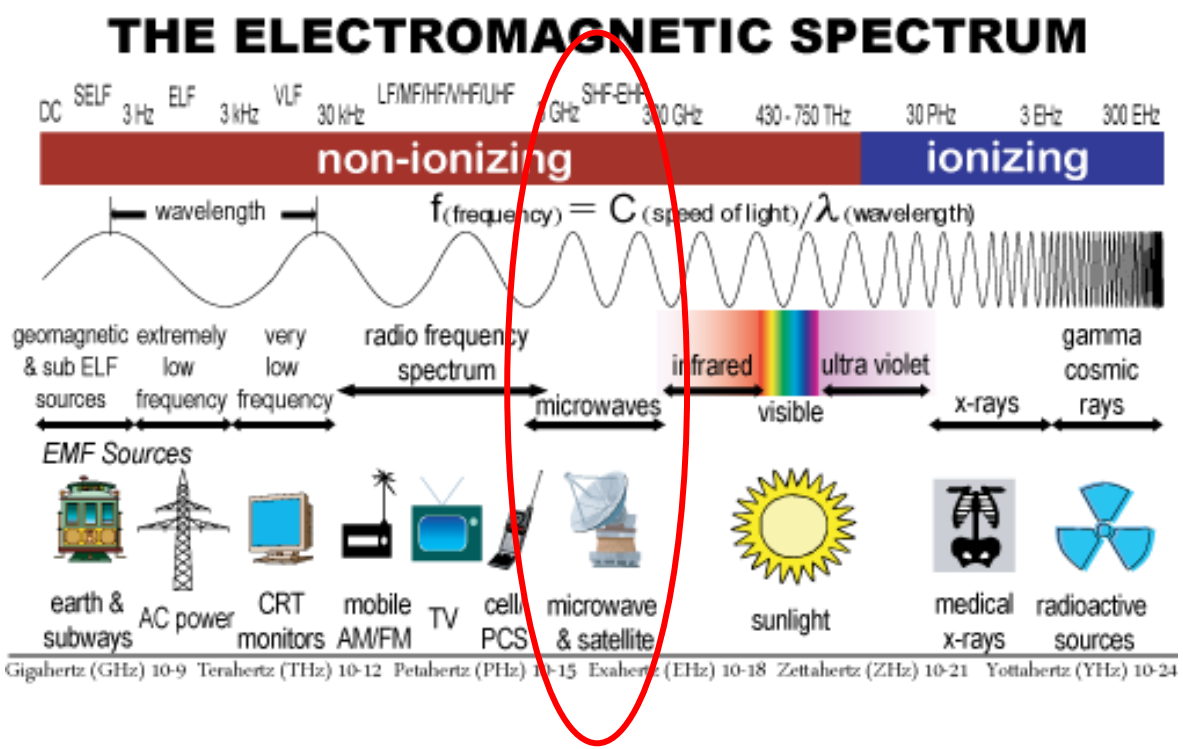
μWave | NATIONAL ENERGY TECHNOLOGY LABORATORY

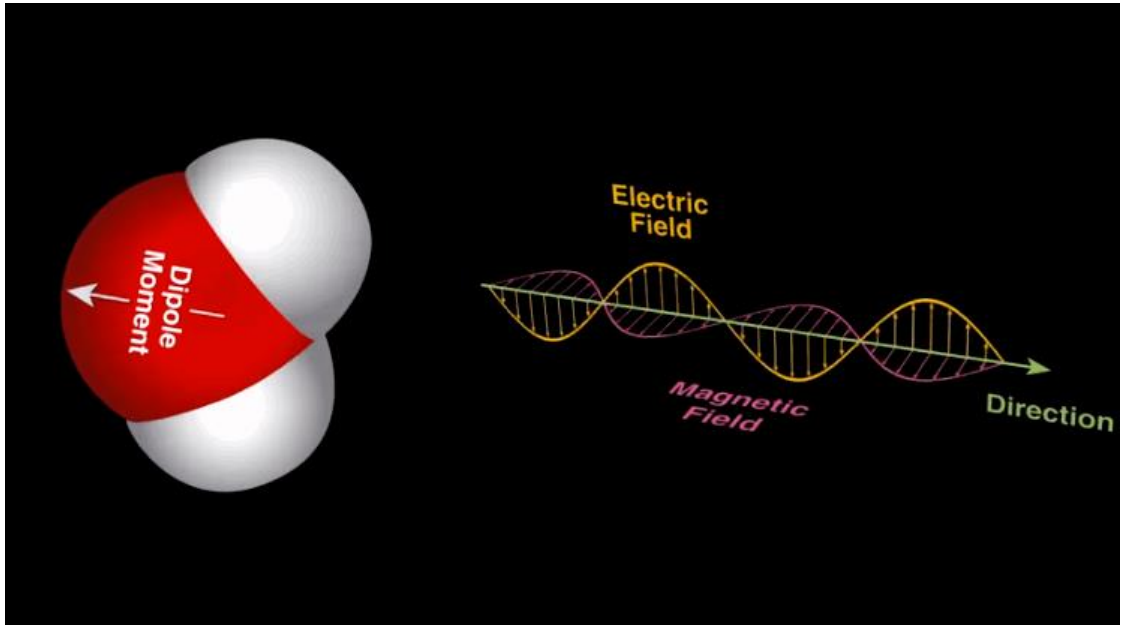
*It's all around us*

- ***Communication***
- ***Navigation & Tracking***
- ***Manufacturing***
- ***Military Applications***
- ***Home Use***

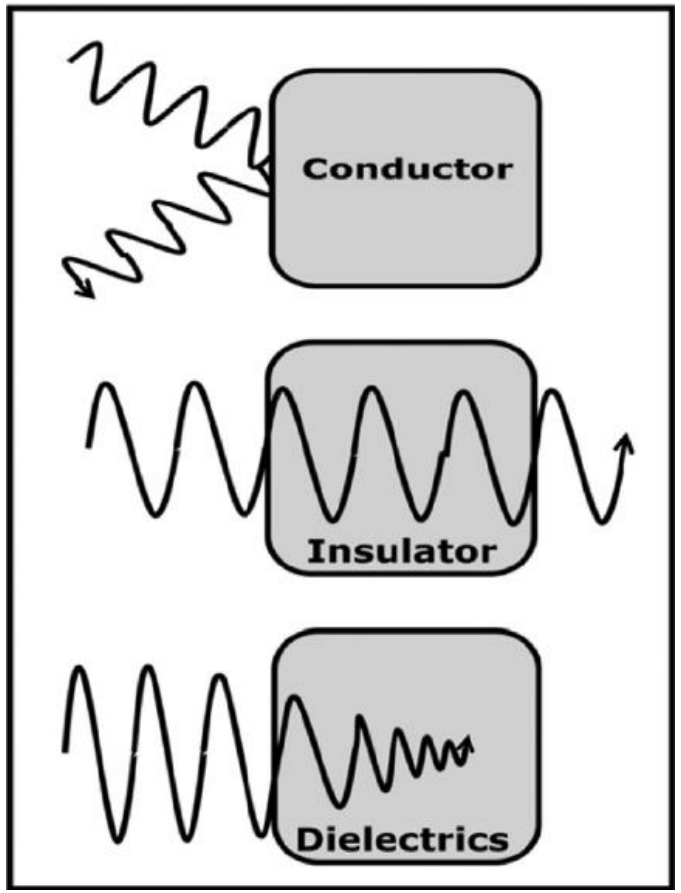


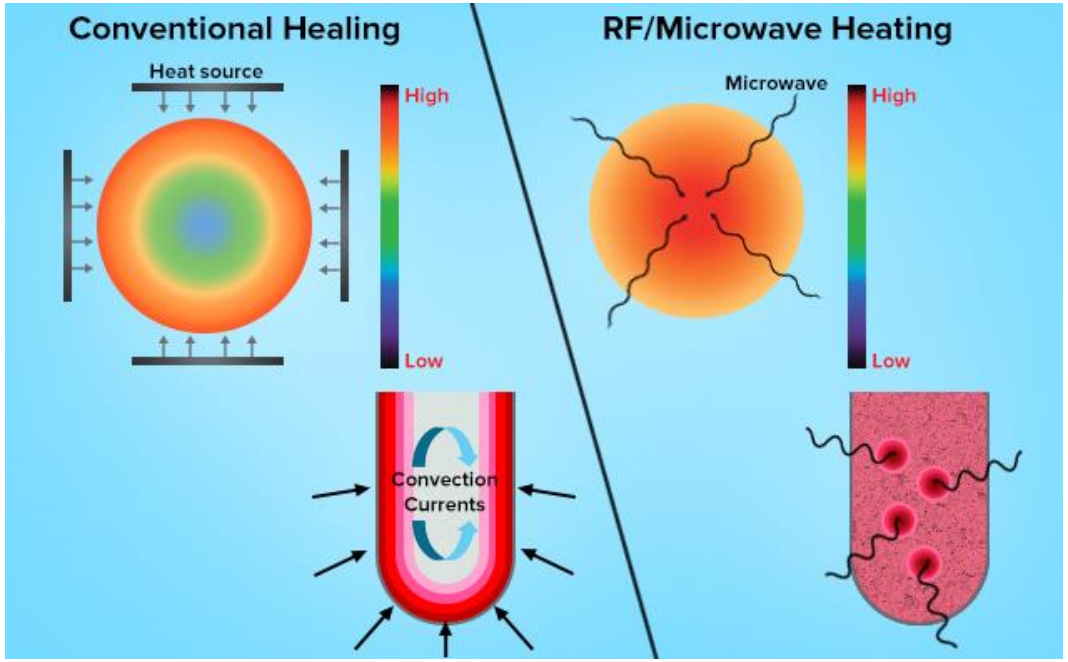

# What are Microwaves?



# Unique Properties



# What Makes MW Appealing?

- ✓ Rapid direct heating
- ✓ Fully electric system
- ✓ Better economics
- ✓ Smaller footprint

**NETL is an early leader in understanding and applying microwave chemistry**

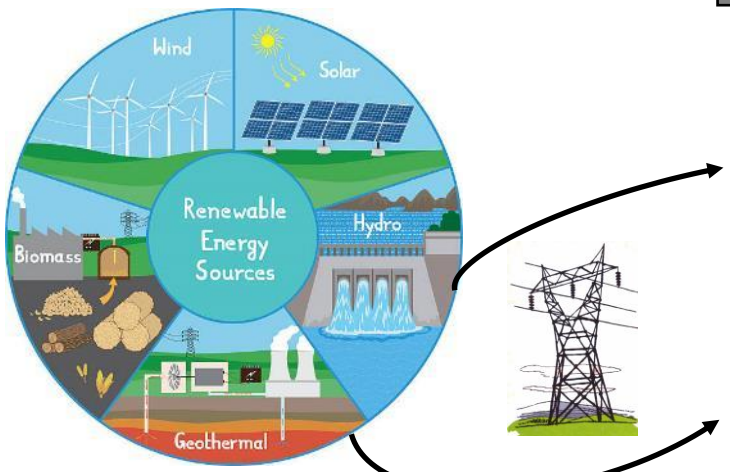
# Enabling Point-of-Use Manufacturing

μWave

NATIONAL ENERGY TECHNOLOGY LABORATORY

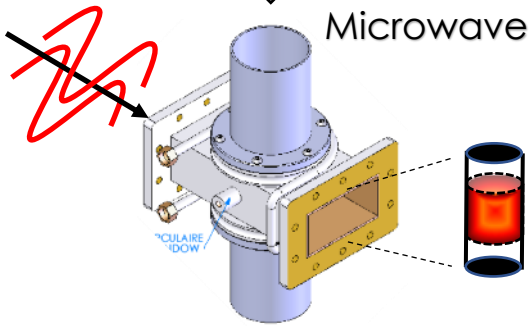
Feedstocks: biomass, plastics, natural gas, $H_20$, $Co_2$, Air

## Green Electrons




## Coupling with intermittent energy resources

Microwave Reactor



## Process Intensification

- Modularity
- Reduction in capex (Low pressures and temps)
- Reduced $CO_2$ emissions

$NH_3$

Carbon Products

Fuels & Chemicals

$H_2$, Syngas

# Future of Manufacturing

- Current manufacturing relies on economy of scale and complex supply chains
- Current events shown setbacks with global trade
- Unconventional feedstocks/circular economy

# Decarbonization Initiatives within DOE

NATIONAL ENERGY TECHNOLOGY LABORATORY

ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

- Energy Earthshots
  - Hydrogen Shot - $1/kg in 1 decade
  - Long Duration Storage Shot – 90% cost reduction for 10+ hr storage
  - Carbon Negative Shot – gigaton scales <$100/ton
  - Enhanced Geothermal Shot – goal of $45/MWh
  - Floating Offshore Wind Shot - goal of $45/MWh
  - Industrial Heat Shot – 85% lower GHG
  - Clean Fuels and Products Shot - 85% lower GHG

**An R&D community approach to leading science and technology innovations to reach the 2050 net-zero carbon goals**

# Ammonia Synthesis

## Market Need

**Haber-Bosch Process**

- High temperature and pressure operations for high efficiency
- Result is super-facilities, only 200 in the world, 5-10 year deployment for new facility

**Today's Need**

- Rapid deployment modular units
- Moderate pressure, moderate temperature
- Ability to integrate with renewable energy

**Low temperature, moderate pressure** operation is possible with **MW heating**

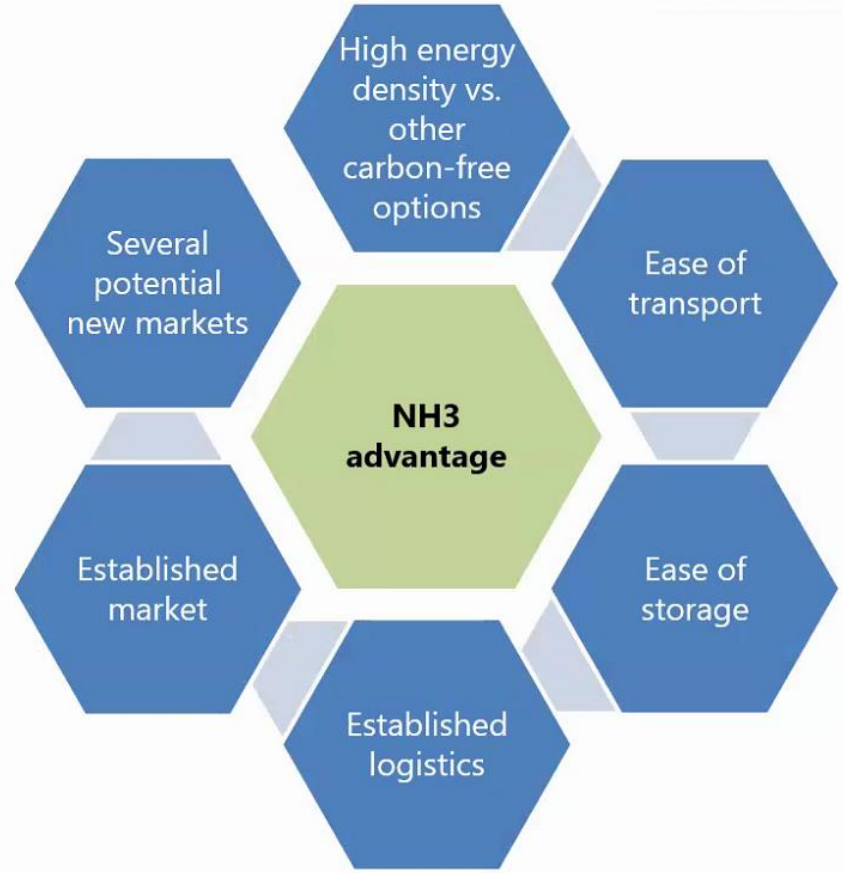


[1] Shacham, M. & Brauner, N. . *Educ. Chem. Eng.* **13**, 17–23 (2015).

# Ammonia and the Hydrogen Economy

- Marine fuels
- Power generation
- Simply as a H2 carrier

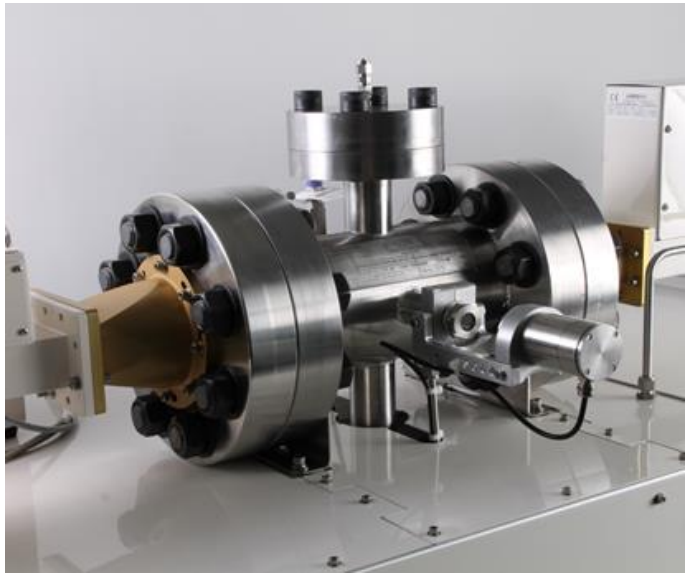
- Fertilizers
- Chemicals
- Other industrial uses




- **High energy density**
- **DoE: ammonia is the lowest cost storage and transport solution for the zero-carbon economy**
- **Global infrastructure for storage and transport already exists**
- **Ammonia will be the basis for hydrogen energy storage**

# Microwave Ammonia Synthesis

- Economic at small scale (5 tons/day)
  - Can service 95% of farms in US
  - Used as NOx abatement process
- Modular plus-up configuration
  - Load follow with renewable energy
  - Add capacity by adding a reactor
- More energy efficient at small scale than HB process
- Fully electric for green ammonia production



# Microwaves in Industry

## Food and Agriculture


Cooking Foods →

Tempering

Pasteurization

Dehydration

Extraction

← Roasting Coffee Beans

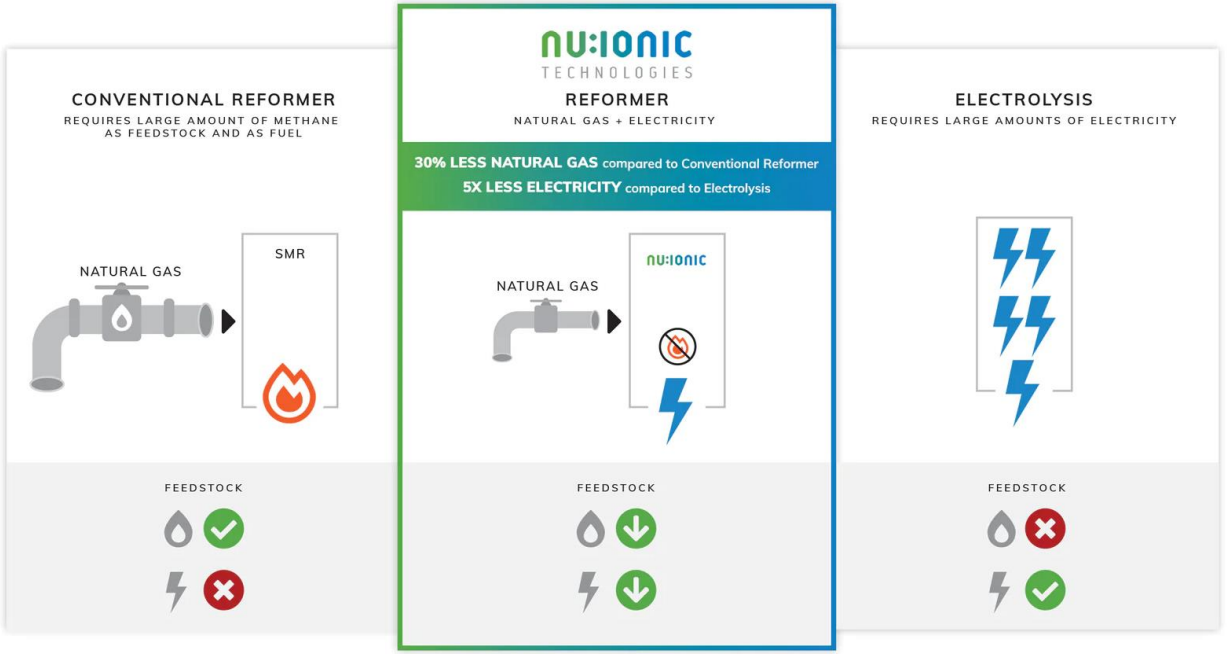
Curtesy of SAIREM

[SAIREM - Microwave and radio frequency]

# Microwaves in Industry

## Emerging Markets

Pyrowave – green recycling of polystyrene




NU:IONIC – microwave driven hydrogen production



Pyrowave: a new generation of plastics - Pyrowave

Nu:ionic - Nu:ionic (nuionic.com)

# NETL's Research Areas

**Electrification**

- Ammonia Synthesis
- Hydrogen Production
- $CO_2$ Capture
- Material Processing

**New Emerging Markets**

- Waste to Fuels
- Plastic Circular Economy
- Critical Mineral Recovery

**Research Tools**

- New microwave adapted characterization equipment
- Predictive models

# Invested R&D Infrastructure

μWave | NATIONAL ENERGY TECHNOLOGY LABORATORY

## *NETL state-of-the-art Reaction Analysis & Chemical Transformation (ReACT) laboratory*

### Microwave Characterization Capabilities

Equipped with advanced custom microwave characterization capabilities

### Versatile Microwave Reactor Systems

One of a kind high pressure and variable frequency reactors, spanning from benchtop to large lab scale

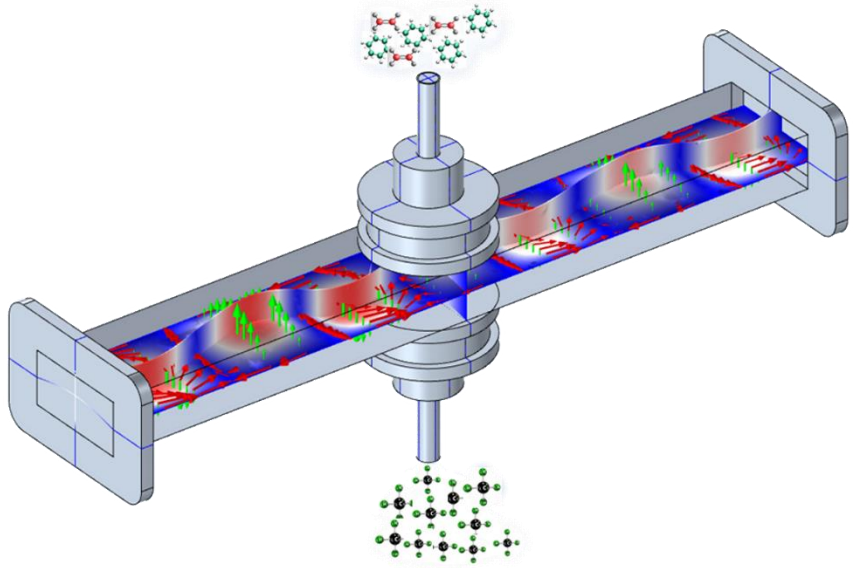
### Advanced Diagnostics for In-situ Characterization

Realtime data from thermal imaging, high speed video, and IR spectroscopy

# Barriers to Integrating with Industry

*Major challenges:*

- Catalyst design
  - No predictive tools
  - Longevity testing
  - Designing for industrial scale
- Technology maturation plans
  - What is the commercial capacity?
  - How do economics compare with current state of art?
- Point of reference at pilot or production scales
  - Field testing technology
  - System integration



# Workforce Development

- **Electrifying the chemical industry pivots skills needed in the workplace**
  - Electricians
  - Controls Development
  - RF engineers
  - Programing
  - Electrical Engineers
  - Physics
  - Computer Science
  - Data Science

- **Examples of Universities with MW Research Programs**
  - West Virginia University - chemistry
  - University of Delaware - chemistry
  - Washington State University - chemistry
  - University of Toledo - hardware
  - University of Colorado - hardware
  - Texas Tech University – oil recovery
  - Clemson University – sensors
  - CalTech – computational
  - UMass Lowell - computational
  - Carnegie Mellon – material synthesis

# Workplace Development

## Observational Needs for New Technology Implementation

- **More cross-cutting within engineering programs**
  - Chemical engineering with electrical engineering and physics
- **Creating teams with diverse backgrounds**
- **Better understanding of the development pathway for a technology**
  - Sensitivity analysis around economics and life cycles
  - What capabilities are needed for a project
  - Identifying pain points within an industry

# Thank You & Contact


**Christina Wildfire**

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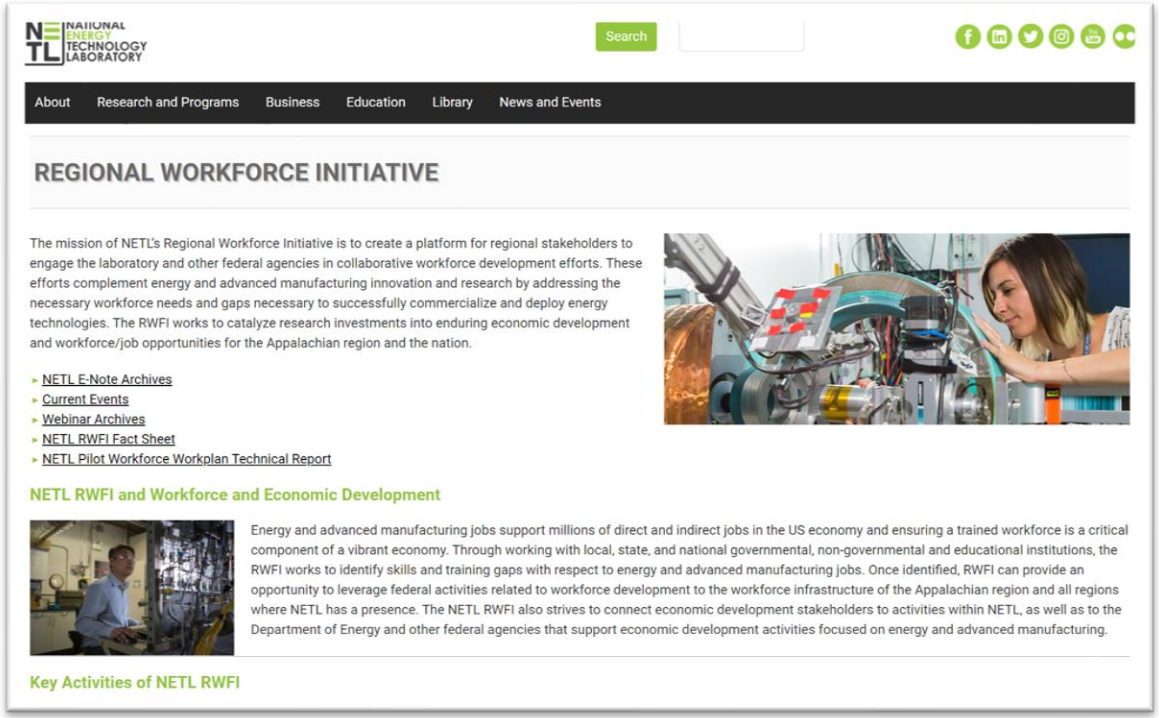
# Economic Development and Workforce Discussion

**Agenda**

- NETL Regional workforce Initiative Updates – Anthony Armaly, NETL RWFI Federal Lead
- Energy 101- Microwave Energy Technology – Christina Wildfire, NETL Research Scientist
- **Energy 101 RWFI Q&A Session**




- www.netl.doe/gov/rwfi
- **Slides will be available on website webinar archives site**