

# Upcycling Associated Natural Gas into Transportable, Value-added Products

Responsible and Sustainable Natural Gas:  
Challenges and Opportunities in Africa

Finding Opportunities: Development of Added-Value Markets

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# Background: Where is Flaring Occurring and Why?

## Top gas flaring countries:

These **seven countries** have been the **top gas flarers** for the last **nine years**.

Together they produce **40%** of the world's oil each year, but account for roughly **2/3 (65%)** of **global gas flaring**.

	Russia
	Iraq
	Iran
	United States
	Algeria
	Venezuela
	Nigeria

- Associated Natural Gas is a by product of oil production
- Flaring occurs due to
  - Safety/operation
  - Economic Reasons
    - Lack of infrastructure
  - Production exceeds takeaway capacity

# NEED: Why Must Flaring be Reduced?

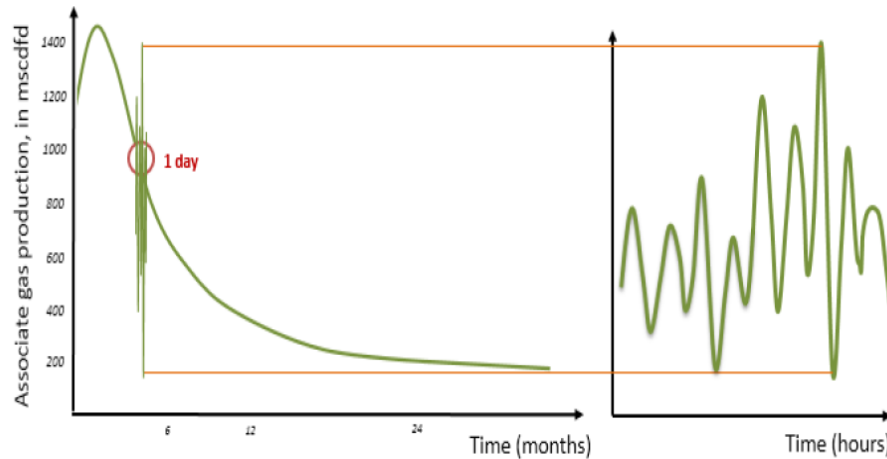
## Flaring and venting are:

- Inefficient and waste of national resources
- Point sources for greenhouse gas emissions of CO<sub>2</sub> and CH<sub>4</sub>
- Lost revenue for the oil or gas producer and mineral-rights owner
- Lost tax revenue: local, state and federal
- Point sources for VOCs and other hazardous air emissions
- Unsustainable business practices

# Challenges for Flare Gas Utilization

- Gas volumes and pressures vary significantly
  - Difficult to size equipment
- Composition varies between basins and wells

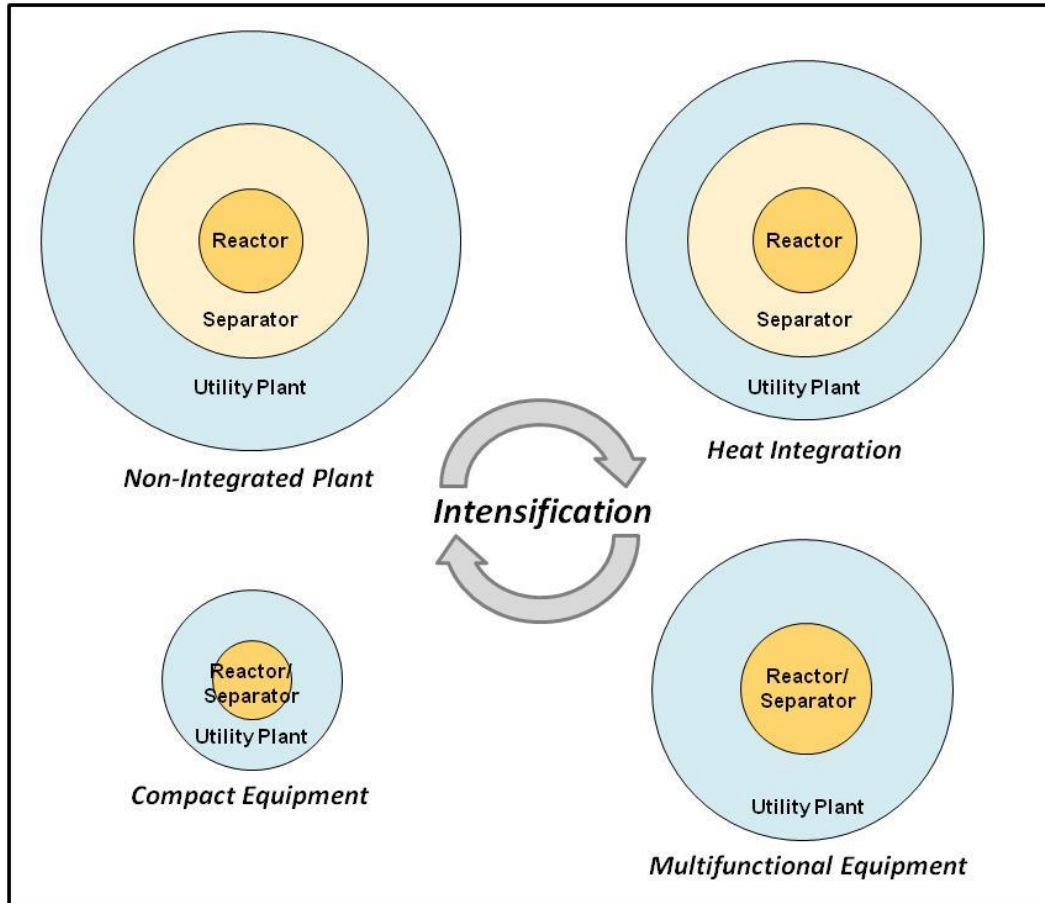
- **Technologies exist today** to convert methane, ethane, etc. to value-added, energy dense liquid and solid products
- However, they are only **efficient and cost effective** at **large-scales** employed in petrochemical industry
- Need alternative technologies for utilizing associated gas
  - New catalysts
  - Alternative conversion technologies (Plasma, Microwaves)
  - Reactor designs





# TECHNOLOGY: Solutions “Must Haves....”

Transformational solutions requiring longer-term R&D effort



- **Compactness** – all system components must be small
- **Integration** - major processing steps must be combined
- **Modularity** – system must be easy to assemble/disassemble and transport between sites
- **Operability** – system must produce product under wide range of rapidly changing conditions
- **Low Cost** – must be manufactured from standardized components employing advanced manufacturing methods

# The Focus of DOE FECM Upcycling Research

## *Natural Gas Upcycling*

Technologies developed to minimize waste of natural gas resources and mitigate greenhouse gas emissions caused by practices like wellhead flaring and venting.

## *Mission of Upcycling Research*

Develop new chemical processes and modular reactor systems that efficiently and economically convert wellhead natural gas into higher-value products that can be more readily brought to market than the natural gas itself.

## *The Need for Natural Gas Upcycling Research*

The conversion of flared natural gas into other chemicals can help industry by enabling profitable use of an otherwise wasted resource while mitigating the environmental impact caused by flaring:

- Developing process-intensified conversion processes powering modular systems that can be deployed at remote locations.
- Creating advanced nano- and micro-scale materials and catalysts that enable significant improvements in natural gas conversion and selectivity to valuable solid and liquid products that are easier to transport.
- Transformative process integration and advance manufacturing concepts that can lead to industry-changing commercial systems.



# DOE/NETL's Existing Upcycling Research Portfolio



Sub-Technology Areas	Number of Existing Projects	Project Foci
Associated Natural Gas to Liquid Products	8	One-Step Process Intensification by Plasma-Assisted Catalytic Synthesis, Modular System for Direct Conversion via Photocatalysis, Core-Shell Oxidative Aromatization Catalysts, Highly Compacted Microchannel Protonic Ceramic Membrane Reactor, Isolated Single Metal Atoms Supported on Silica, Partial Oxidation over Multifunctional 2-D Materials, Low-Temperature Chemical Looping Reforming Catalysts, Novel Modular GTL Reactor
Associated Natural Gas to Hydrogen & Solid Products	4	Microwave Catalysis for Process Intensified Modular Production of Carbon Nanomaterials, Modular Processing of Flare Gas for Carbon Nanoproducts, Softox for Stranded Gas Utilization, Gas to Carbon Fiber Crystals
Total Existing Intramural Fundamental Research Projects	12	

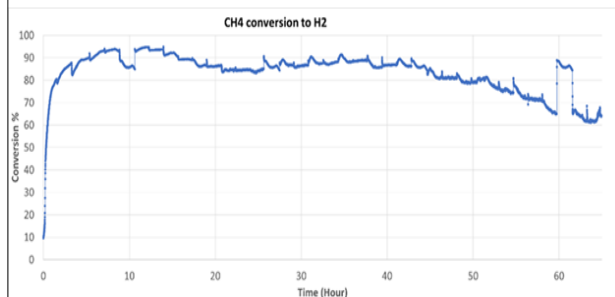
## Participants Conducting Upcycling Research



# DOE/NETL's RIC Upcycling Research Portfolio

## Hydrogen and Carbon via pyrolysis

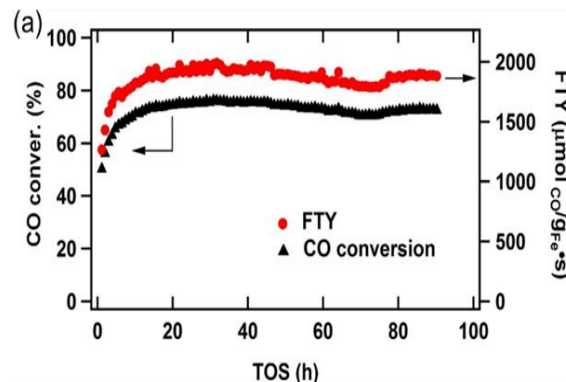
Percentage of CH<sub>4</sub> conversion to H<sub>2</sub> during 65 hr. fluid bed methane pyrolysis test with NETL catalyst (425 g) at 700 °C



### EY21 Work

- Optimization of patented NETL catalyst
- Systems analysis on pyrolysis process

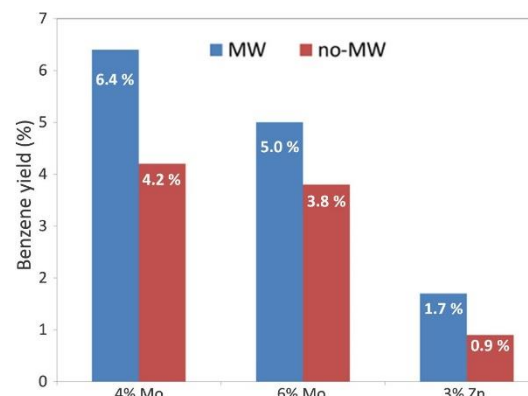
## Plasma-Olefins Process



### EY21 Work

- Scale olefin catalyst production
- Validation of large-scale catalyst batches
- Process design and optimization

## Microwave synthesis of BTX



### EY21 Work

- Optimization of heat/MW field in catalyst bed
- Optimize Mo/ZSM-5 MW activity
- TEA on microwave system

## Associated Natural Gas Utilization and Mitigation Assessment

### EY21 Work

- Conduct market analysis on liquid-based chemical intermediates
- Identify existing and emerging markets for these chemicals



# Questions?

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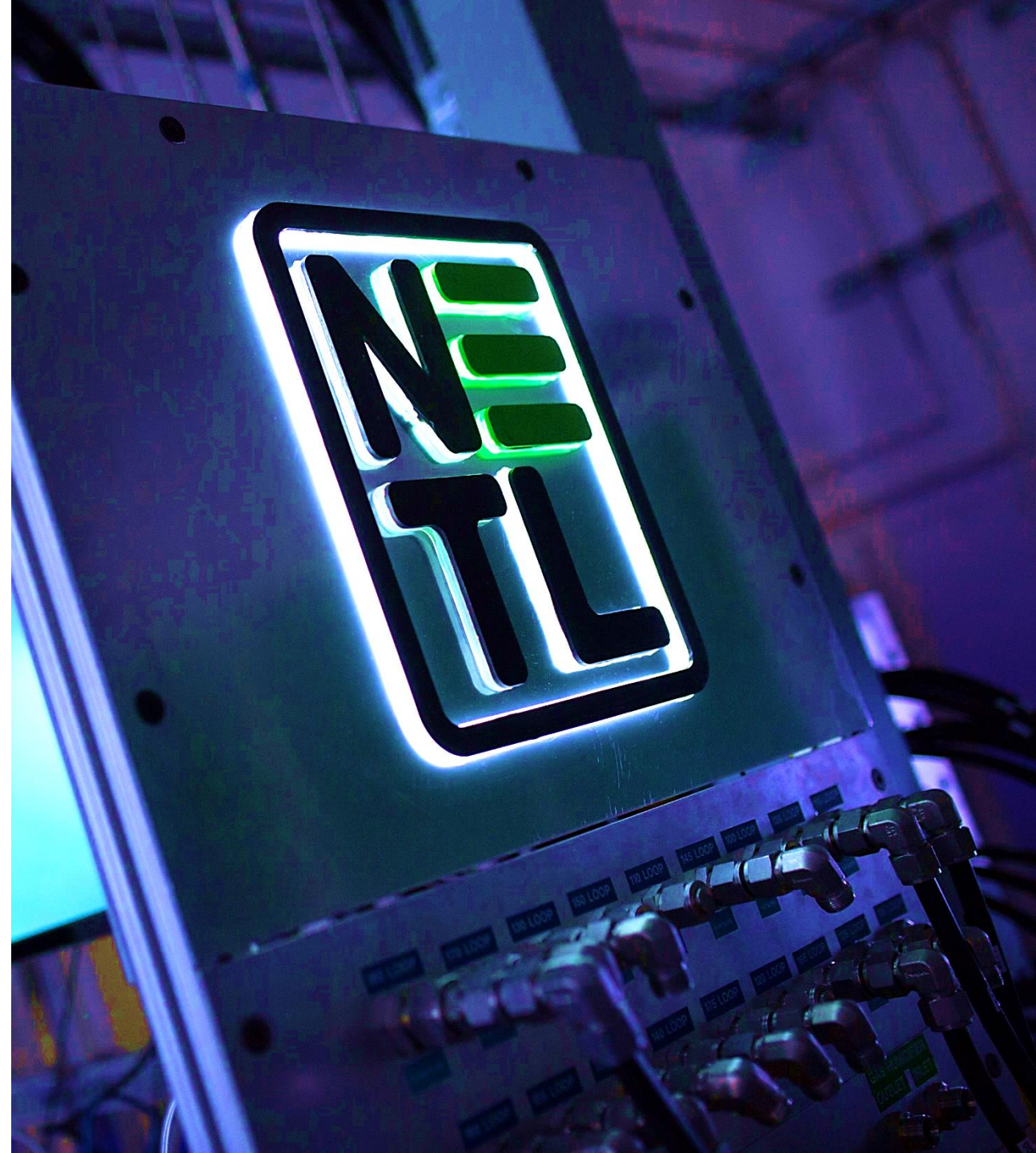
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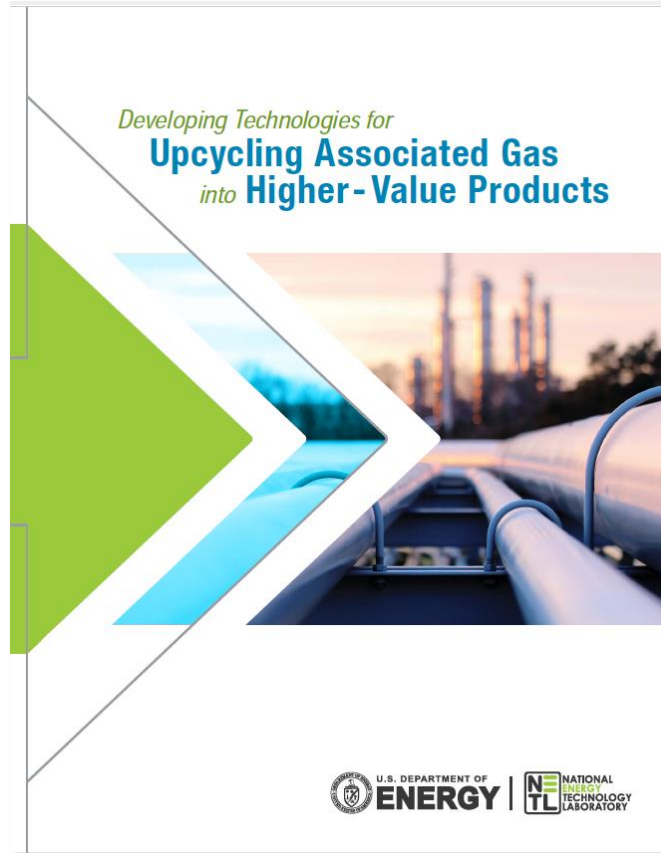


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<https://netl.doe.gov/sites/default/files/2020-12/Upcycling-Associated-Gas-into-Higher-Value-Products-12-2020.pdf>