U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

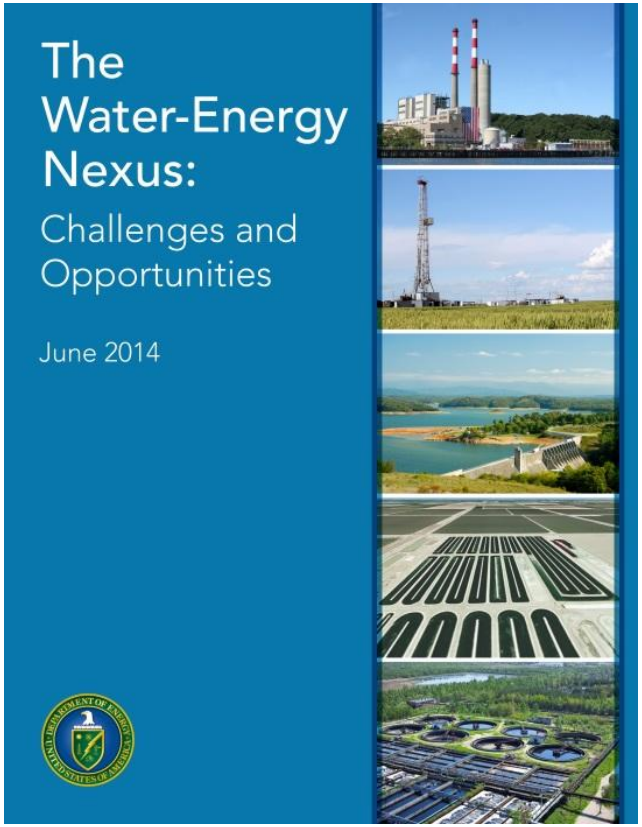
Biofuels and Bioproducts from Wet and Gaseous Waste Streams: Challenges and Opportunities

Berkeley City Club

June 6-7, 2017

Water-Energy Nexus: DOE Engagement

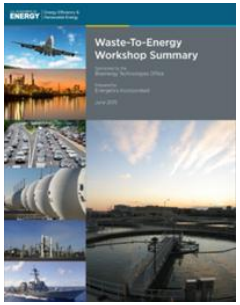
- GAO issued report in Fall 2012, fifth in a series on energy-water nexus
- GAO found that the DOE was not doing enough to meet its obligations under the Energy Policy Act of 2005
- DOE agreed with the GAO, launched a cross-cutting Water-Energy Tech Team (WETT)
- Water-Energy Nexus a priority for Secretary Moniz
- WETT produced a comprehensive report in June, 2014
- Intended as a first step, an invitation to dialogue with stakeholders at multiple levels
- Energy for and from water was a key technology focus

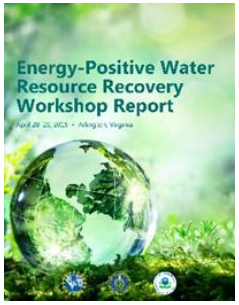


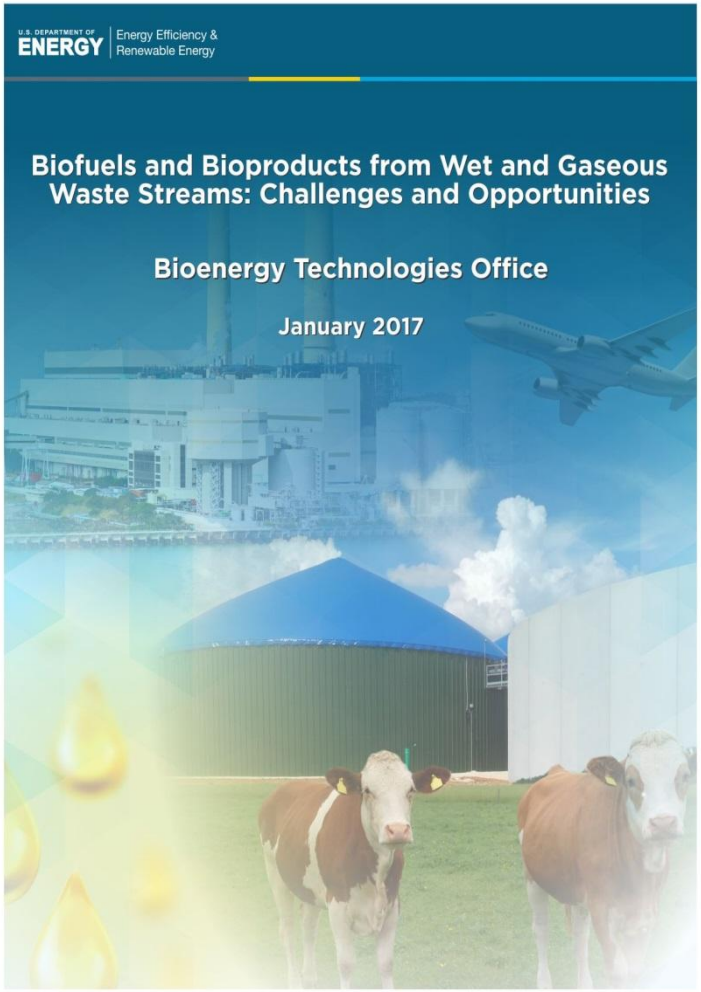
Download the full report at energy.gov

Biofuels and Bioproducts from Wet and Gaseous Waste Streams

Building off of series of four workshops and other recent interagency collaborations.







U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Energy from Waste Streams is Equivalent to Over 6% of 2015 Energy from Petroleum

Feedstocks	Annual Raw Resource Generation[1]			% of 2015 Petroleum Consumption[3]	
	Estimated Annual Resources	Inherent Energy Content (Trillion Btu)	Inherent Fuel Equivalent (MM GGE)[2]	All uses	Transportation Only
Wet Feedstocks	77.17 MM Dry Tons	1,078.6	9,290.8	2.93%	4.08%
Wastewater Residuals	14.82	237.6	2,046.6	0.64%	0.90%
Animal Waste	41.00	547.1	4,713.0	1.48%	2.07%
Food Waste[4]	15.30	79.6	685.3	0.22%	0.30%
Fats, Oils, and Greases	6.05	214.3	1,845.9	0.58%	0.81%
Gaseous Feedstocks		733.6	6,319.8	1.99%	2.77%
Biogas[5]	420 BCF	430.5	3,708.6	1.17%	1.63%
CO_2 Streams	3,142 MM Tons	-	-	-	
Associated Natural Gas	289 BCF	303.1	2,611.2	0.82%	1.15%
Other Waste Feedstocks		526.1	4,531.6	1.43%	1.99%
Glycerol	0.6 MM Tons	8.7	75.1	0.02%	0.03%
Black Liquor	44 MM Tons	517.4	4,456.5	1.40%	1.96%
DDGS	44 MM Tons	n/a	n/a	0.82%	1.15%
Total		**2,338.3**	**20,142.2**	**6.34%**	**8.84%**

Petroleum Consumption (2015):

7.13 Billion Barrels

(4.99 billion bbl for Transportation Only)

Equivalent to:

36,870 Trillion Btu

(26,454 TBtu for Transportation Only)

Fuel Equivalent of:

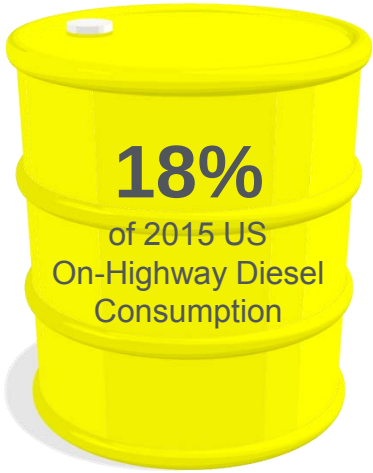
317,600 MM GGE

(227,875 MM GGE for Transportation Only)

[1] Data from Table ES.1 of "Biofuels and Bioproducts from Wet and Gaseous Waste Streams: Challenges and Opportunities." (Revised), published by the Bioenergy Technologies Office.
[2] 116,090 Btu/gal. This does not account for conversion efficiency.
[3] Petroleum consumption data from Table 3.5, Table 3.6, Table 3.7c, and Table 3.8c of EIA Monthly Energy Review, 2015 Total Values
[4] The moisture content of food waste varies seasonally, ranging from 76% in the summer to 72% in the winter.
[5] Methane potential. This does not include currently operational landfill digesters (>1,000 billion cubic feet [Bcf] annually).

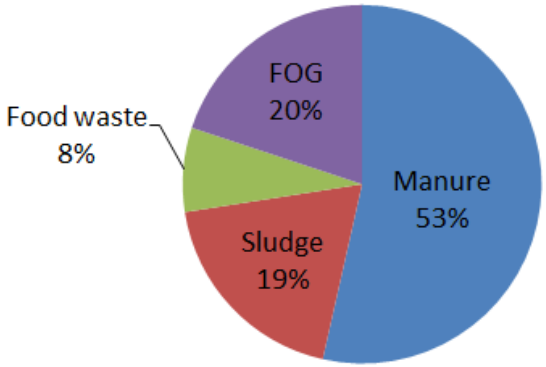
Initial Results

Wet WtE resources have the equivalent energy content of about one quad or 7 billion diesel gallon equivalent (DGE) per year.



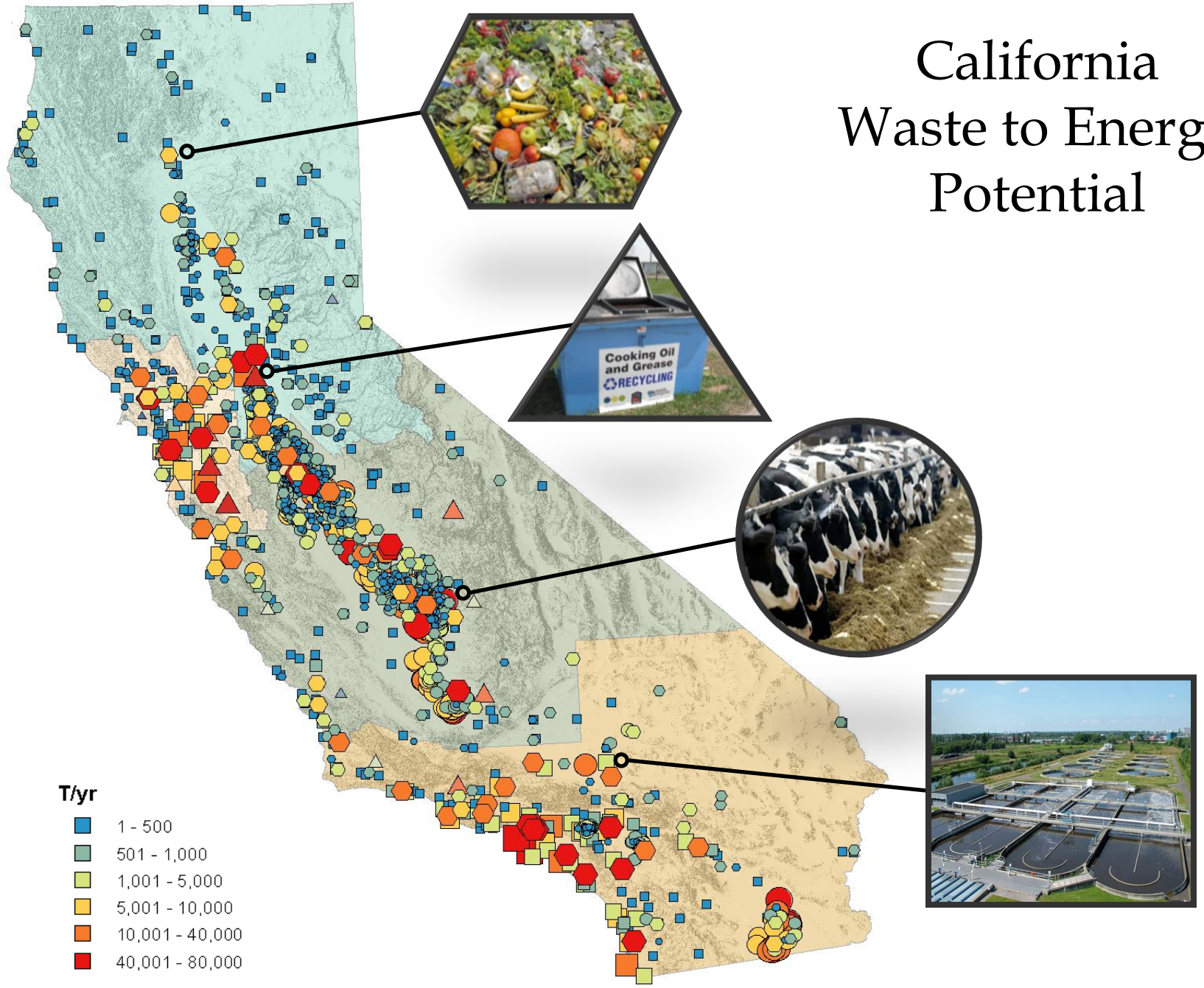
- Wet WtE resources include:
  - Animal manure
  - Fats, oils, and greases (FOG)
  - Wastewater sludge
  - Food waste
- **About half of this potential is generated by animal manure**
- Food waste, while relatively small at the national level, may be an important blending agent in highly concentrated locations.

Wet WtE Resource Potential



Milbrandt et al. 2017. Pending publication. *Biomass and Bioenergy*.

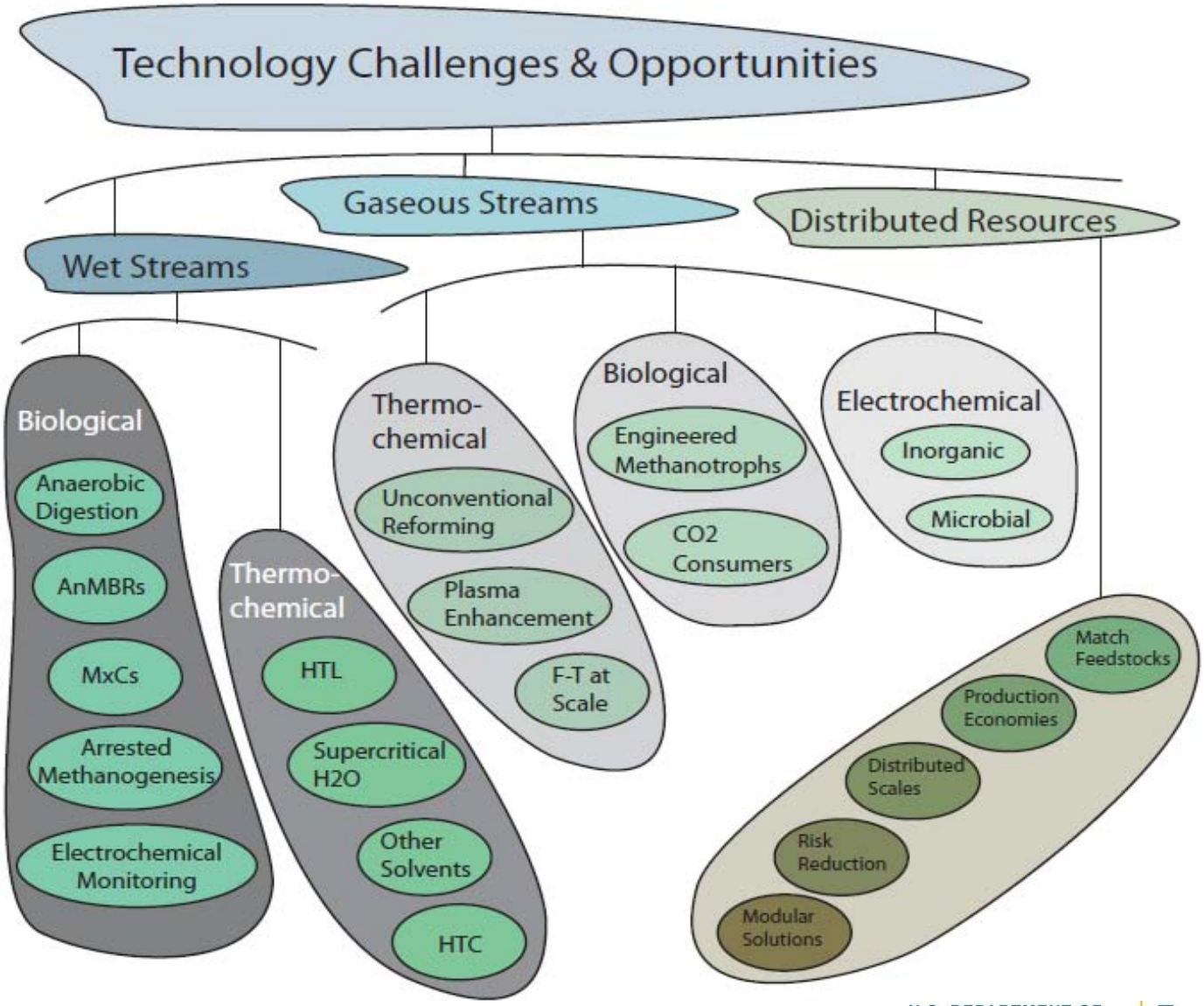
California Waste to Energy Potential



Distributed Resource Challenges

- Transportation of Wet Feedstocks Cost-Prohibitive
- Production of Transportable Intermediates
- Integration with Regional Upgrading Facilities
  - Pacific Northwest National Lab working on the techno-economics of this problem as one next step
- Conversion Technologies Must Match Scale of Feedstock Availability
  - Modular solutions one possibility
  - Economies of Mass Production instead of/in addition to Scale
  - Take Advantage of Learning Curves
- Not your Grandmother's Fuel Production Problem
  - Traditional Petroleum Refinery Scale is not an option
  - Bioproducts probably necessary to enable biofuels in short-to-medium term
  - Wet and Gaseous Feedstocks Require Different Conversion Technologies Than Dry Solid Materials
    - Also sidestep some key challenges

Potential Areas for Technology RDD&D



Key Wet and Gaseous Feedstocks Messages

- Wet and gaseous feedstocks constitute a significant resource
- These feedstock streams already exist, in distributed form
- In many cases, they constitute a clear and present problem to be solved
  - This problem has garnered serious congressional attention
  - The streams are only going to get larger as population grows
- Wet and gaseous feedstocks require different conversion strategies than terrestrial feedstocks
- The techno-economic and life cycle considerations for these resources are distinct from those for traditional biomass
- While market challenges remain, these resources could present a leading-edge niche opportunity for the bioeconomy of the future
- Commercial solutions are just beginning to enter the market

Workshop (Series?) Objectives

- Translate Findings into Tangible Market Success
  - What will it take to actually make biofuels and bioproducts out of these feedstocks profitably at appropriate scales?
  - Inform future DOE activities
    - Small Business Innovation Research (SBIR) program
    - Funding Opportunity Announcement (FOA) topics
      - As appropriations permit
    - Lab Projects
      - Technology-focused
      - Analysis and Modeling
  - Facilitate additional collaborations
    - Interagency (Federal)
    - Federal and State
    - Public/Private
    - Private/Private
- Other States in FY 18-19 ???? (TX??)

Workshop Design Principles

- Include full value chain (feedstocks, technologies, resource handling, customers, government at all levels)
- **Emphasis on participant input (breakout groups)**
  - Speakers designed to frame discussion
  - Diverse mix of participant types in each breakout session
  - Switch between days one and two to balance continuity and novelty
- Focus on unique elements of California
  - Strong state government participation
  - Explore multi-level policy interactions
  - Connect feedstocks, technologies, policies, practices, and markets
  - Ideally, drill down to specific challenges and opportunities
- Open with California Panel

Questions?

Mark Philbrick
Mark.Philbrick@hq.doe.gov

General Breakout Guidelines

- Loose Content formula:
  - What are the challenges/opportunities?
  - Why are they challenges/opportunities
  - What might be done about them
- Rough Process Outline
  - Start with general topical brainstorming
  - Prompted in most cases by straw categorization
    - Build on what we already know
  - Move to Individual Brainstorming on large post-its
  - Group Discussion and Prioritization
  - Summary for Report Out
- Facilitators Empowered to adjust on the fly based on group dynamics
  - Teasing optimal value out of participant bandwidth investment

Breakout Session 1: Policy Obstacles and Enablers

- Group A (Facilitator: Lauren)
  - Member's Lounge (2nd Floor)
- Group B (Facilitator: Robert)
  - Drawing Room (1st Floor)
- Group C (Facilitator: Roy)
  - Venetian Room (2nd Floor)
- Group D (Facilitator: Mark)
  - Ballroom (2nd Floor)

General Breakout Guidelines

- Loose Content formula:
  - What are the challenges/opportunities?
  - Why are they challenges/opportunities
  - What might be done about them
- Rough Process Outline
  - Start with general topical brainstorming
  - Prompted in most cases by straw categorization
    - Build on what we already know
  - Move to Individual Brainstorming on large post-its
  - Group Discussion and Prioritization
  - Summary for Report Out
- Facilitators Empowered to adjust on the fly based on group dynamics
  - Teasing optimal value out of participant bandwidth investment

Breakout Session 2: Feedstocks (Stakeholder Perceptions)

- Group A (Facilitator: Lauren)
  - Member's Lounge (2nd Floor)
- Group B (Facilitator: Robert)
  - Drawing Room (1st Floor)
- Group C (Facilitator: Roy)
  - Venetian Room (2nd Floor)
- Group D (Facilitator: Mark)
  - Ballroom (2nd Floor)

General Breakout Guidelines

- Loose Content formula:
  - What are the challenges/opportunities?
  - Why are they challenges/opportunities
  - What might be done about them
- Rough Process Outline
  - Start with general topical brainstorming
  - Prompted in most cases by straw categorization
    - Build on what we already know
  - Move to Individual Brainstorming on large post-its
  - Group Discussion and Prioritization
  - Summary for Report Out
- Facilitators Empowered to adjust on the fly based on group dynamics
  - Teasing optimal value out of participant bandwidth investment

Breakout Session 3: Customer Considerations

- Group E (Facilitator: Lauren)
  - Member's Lounge (2nd Floor)
- Group F (Facilitator: Robert)
  - Drawing Room (1st Floor)
- Group G (Facilitator: Roy)
  - Venetian Room (2nd Floor)
- Group H (Facilitator: Mark)
  - Ballroom (2nd Floor)

General Breakout Guidelines

- Loose Content formula:
  - What are the challenges/opportunities?
  - Why are they challenges/opportunities
  - What might be done about them
- Rough Process Outline
  - Start with general topical brainstorming
  - Prompted in most cases by straw categorization
    - Build on what we already know
  - Move to Individual Brainstorming on large post-its
  - Group Discussion and Prioritization
  - Summary for Report Out
- Facilitators Empowered to adjust on the fly based on group dynamics
  - Teasing optimal value out of participant bandwidth investment

Breakout Session 4: Summarization/Next Steps

- Group E (Facilitator: Lauren)
  - Member's Lounge (2nd Floor)
- Group F (Facilitator: Robert)
  - Drawing Room (1st Floor)
- Group G (Facilitator: Roy)
  - Venetian Room (2nd Floor)
- Group H (Facilitator: Mark)
  - Ballroom (2nd Floor)