C-CHANGE
Grass to Gas:
Powering Sustainable Energy with Sustainable Agriculture

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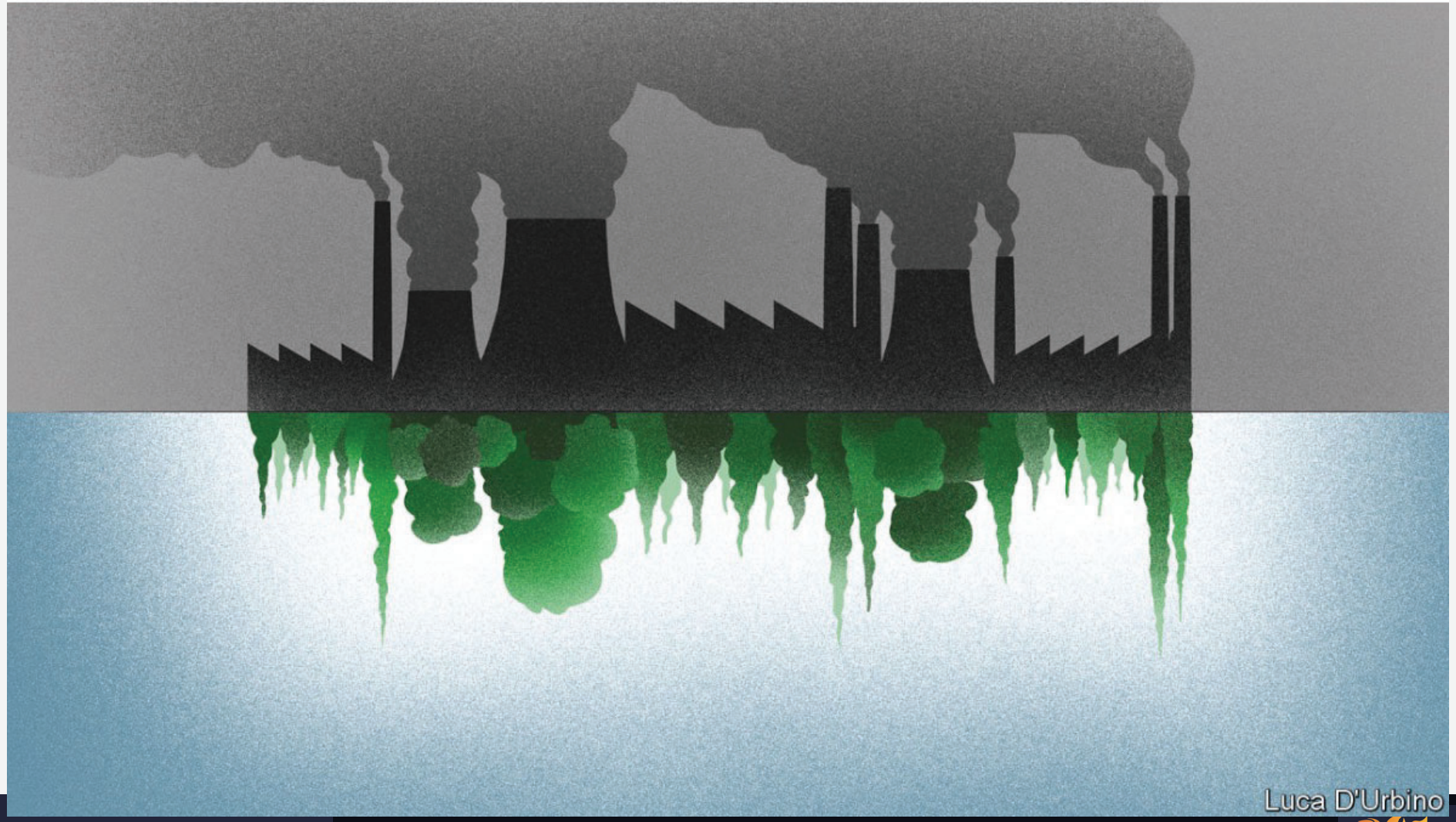
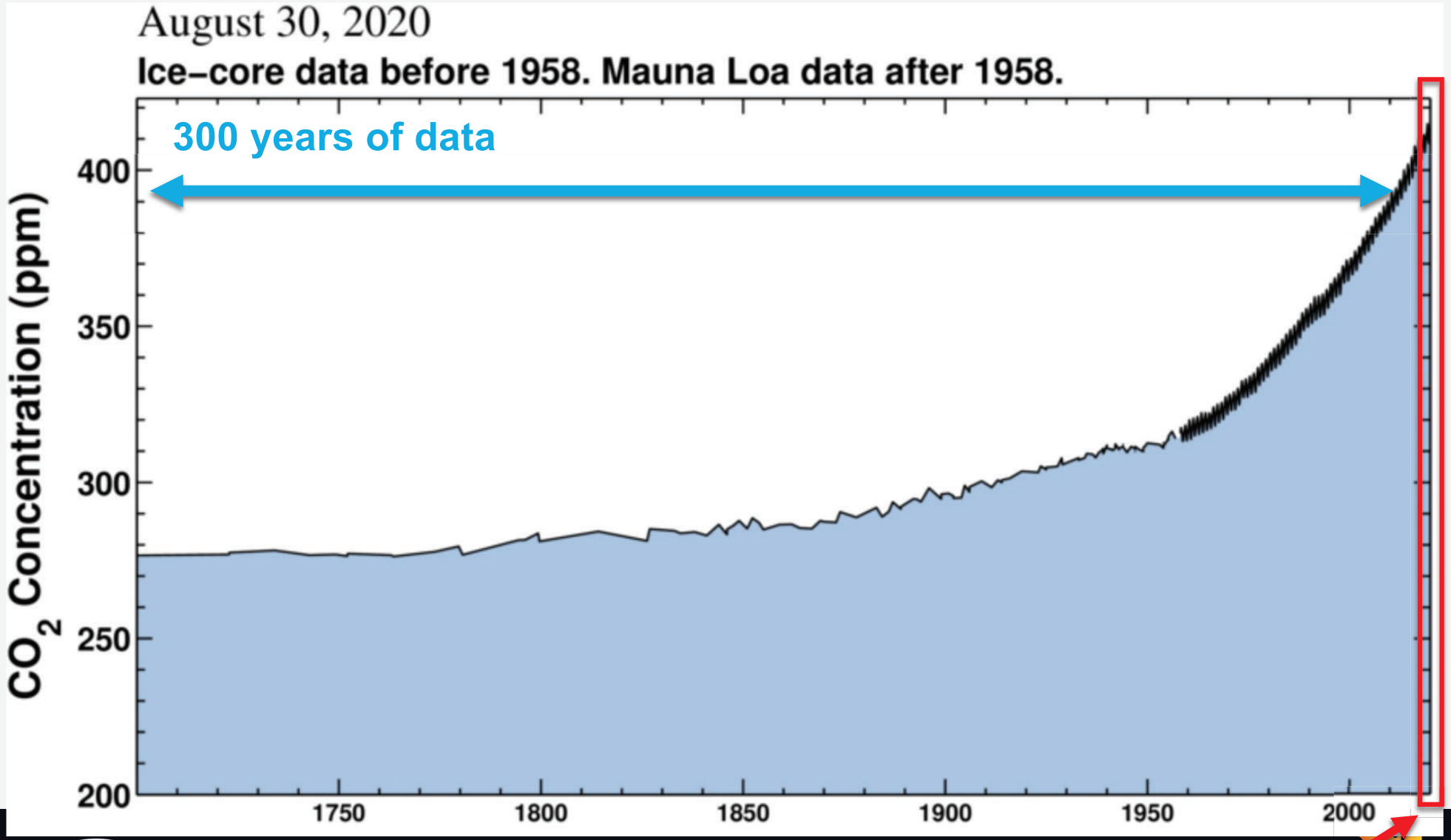
The role of Photosynthesis



The Economist. Oct. 11, 2018

Atmospheric CO_2 is rising rapidly



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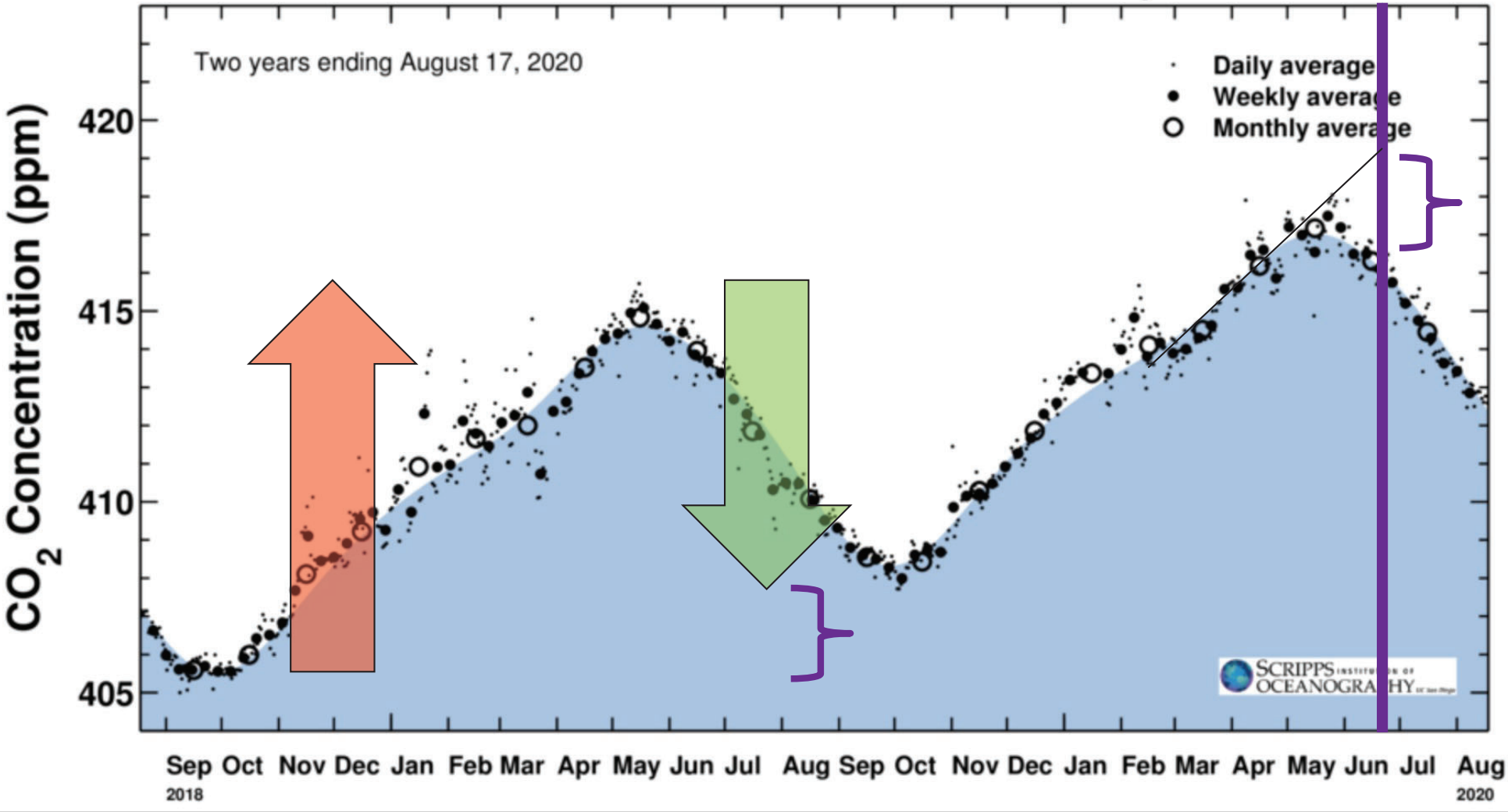
https://scripps.ucsd.edu/programs/keelingcurve/

The Power of Photosynthesis

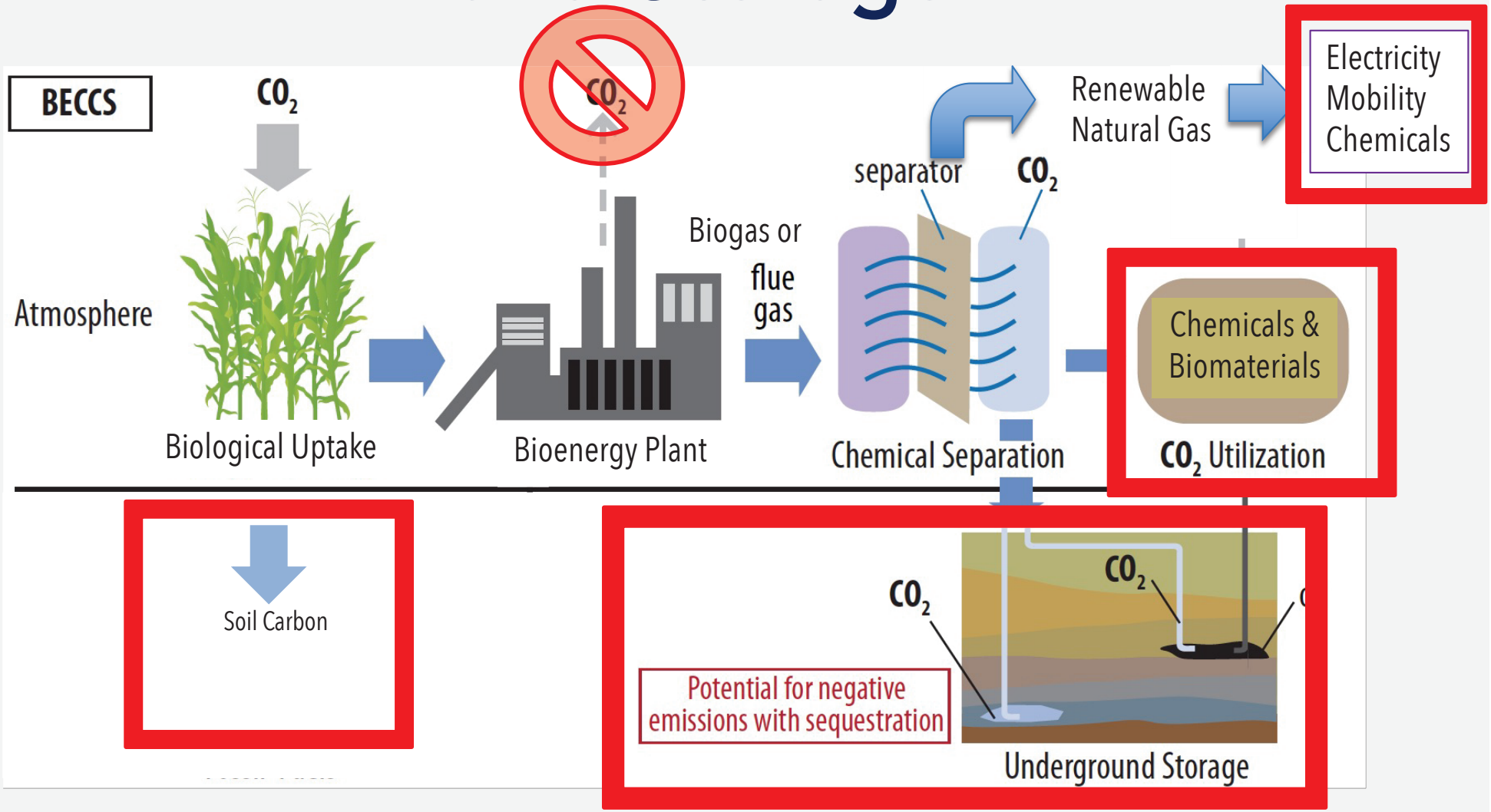
Latest CO_2 reading: 412.59 ppm

August 17, 2020

https://scripps.ucsd.edu/programs/keelingcurve/



Biomass Energy Carbon Capture and Storage



IOWA STATE UNIVERSITY

ROESLEIN ALTERNATIVE ENERGY, LLC

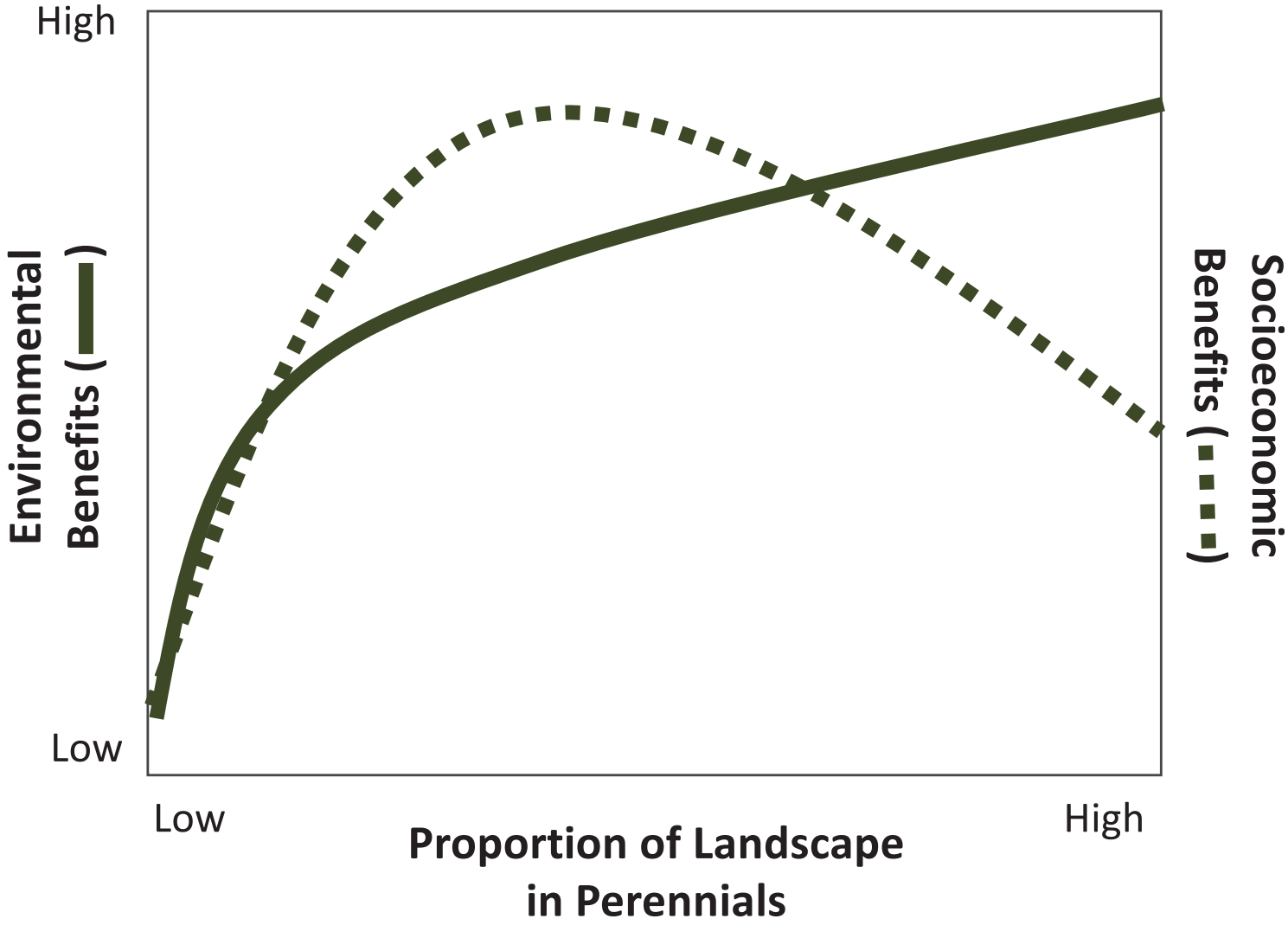
FDCE Conservation & Bioenergy

USDA ARS

STRIPS: Science-based Trials of Rowcrops Integrated with Prairie Strips

Image: Tama Co., Iowa; Omar de Kok-Mercado

Disproportionate Benefits Hypothesis



Sources: Schulte et al. 2006 JSWC; Asbjornsen et al. 2014 RAFS

Transdisciplinary Research & Demo on Experimental Catchments & Commercial Farms

Image: Cass Co., Iowa; Matt Stephenson

Extension & Outreach

Image: Cherokee Co., Iowa; Nick Ohde, PFI

Farmer Partners

Photo: Tama Co., Tim Youngquist

Highlights from a Decade of Research on Prairie Strips

Strategically adding 10% prairie to no-till corn-soy fields:

- 37% reduction in water runoff
- 95% reduction in sediment loss
- 77% reduction in phosphorus runoff
- 70% reduction in nitrogen runoff
- 70% reduction in subsurface NO_3-N concentrations (not tiled)
- 75% reduction in N_2O-N emissions at footslope position
- More than triple pollinator and double bird abundance
- Influence on crop yield proportionate
- No additional weed problems
- Cheaper than installing terraces; cost comparable to cover crops

Sources: Schulte et al. 2017 PNAS; Iqbal et al. 2015 SSSAJ; Kordbacheh et al. 2020; Damiano & Niemi Forthcoming

Prairie strips now a U.S. federally defined Conservation Reserve Program practice (CP-43)

Source: STRIPS Unpublished data, USDA 2020

Image: Tama Co., Iowa; Omar de Kok-Mercado

C-CHANGE Grass-to-Gas Value Chain




Feedstock Production

- Herbaceous biomass including perennial grasses, double crops, crop residues
- Manure from swine, dairy, beef cattle, poultry
- Food, processing wastes

Anaerobic Digestion (AD)

- Single, 2-stage
- Mesophilic, Thermophilic
- Pretreatment, cotreatment
- Process intensification and automated control
- Biogas (CH_4, CO_2)
- Digestate (liquids, solids)

Co-product Processing

- Biogas separation
- RNG* upgrading to liquid fuels and chemicals
- On-farm cogeneration of electricity, heat
- Solids separation
- Drying, composting
- Torrefaction, gasification

Distribution and Markets

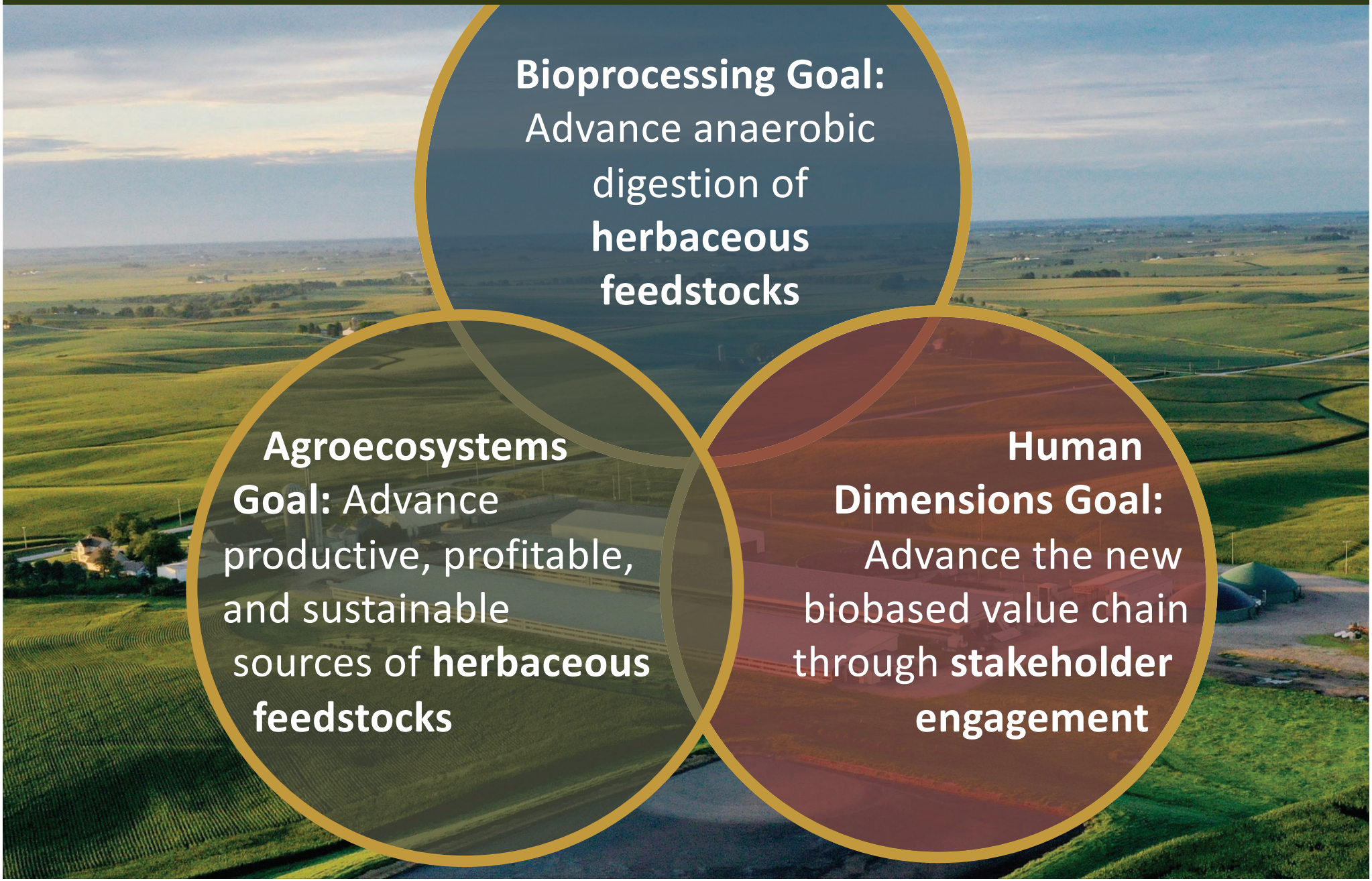
- RNG* and CO_2 for utilization, sequestration
- Slurry fertilizer
- Pellets, bedding & fiber, compost
- Process heat, activated carbon products, biochar
- Ecosystem services^

Societal Value

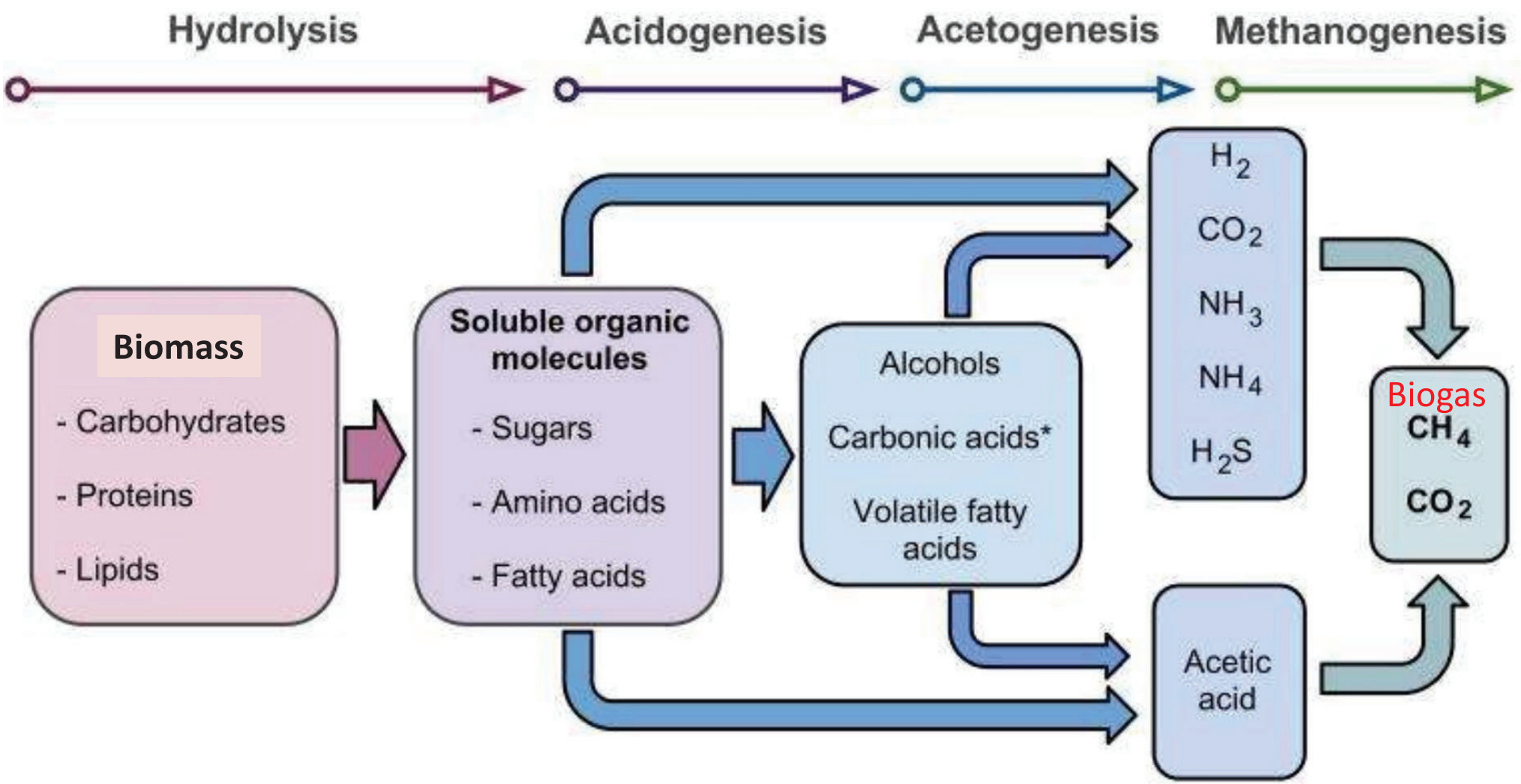
- Renewable products and services
- Private and public revenue
- Jobs
- Healthy environments
- Lower risk, lower cost, more resilient agricultural systems

**RNG = Renewable Natural Gas; may be injected into pipeline or sold as Compressed Natural Gas (CNG). ^Ecosystem services may include improved carbon and nutrient cycling, soil retention/regeneration, clean air, clean water, flood control, and wildlife and pollinator habitat.*

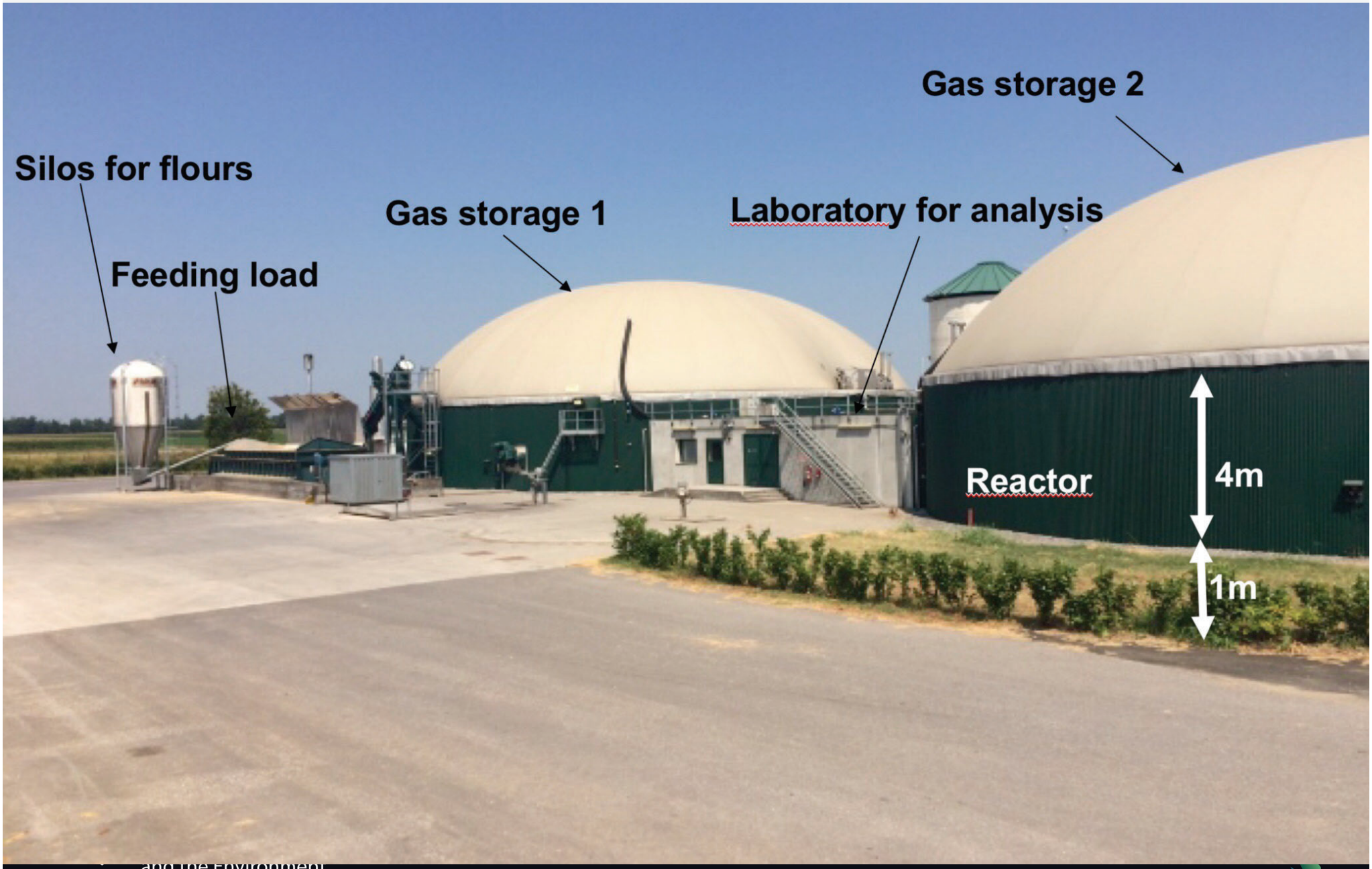
C-CHANGE Grass-to-Gas



Anaerobic Digestion



Typical Farm Digester



Biogas and Renewable Natural Gas (RNG)

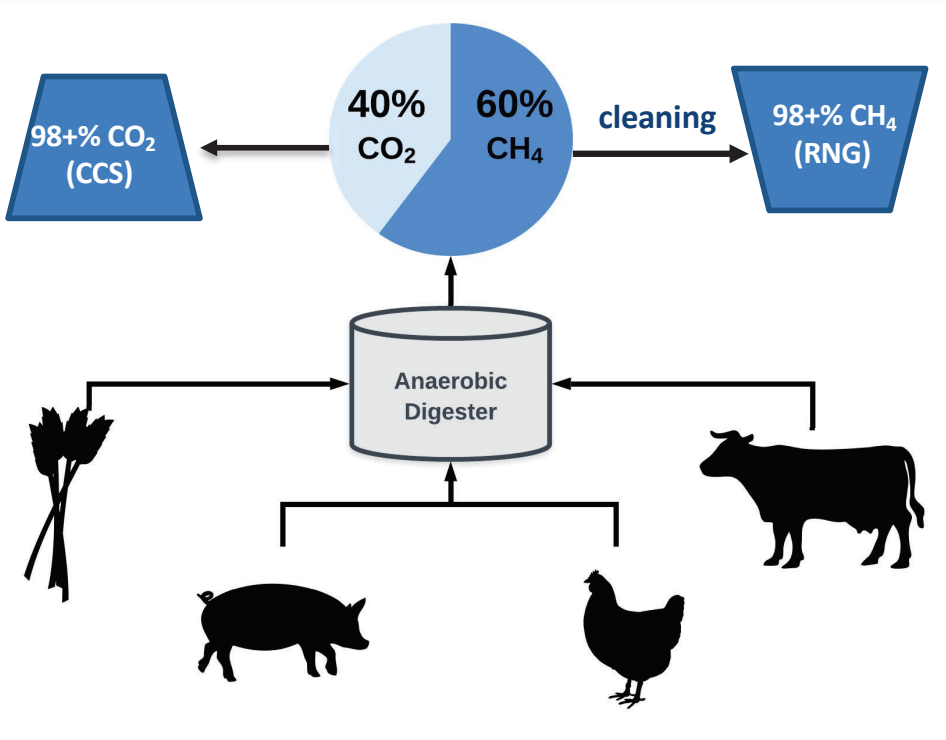
Biogas, the gaseous product of the anaerobic decomposition of organic matter, is about 60:40 CH_4:CO_2. Separating the CH_4 produces RNG, plus a nearly pure byproduct CO_2 resource.

3 ways Renewable Natural Gas can reduce greenhouse gas emissions:

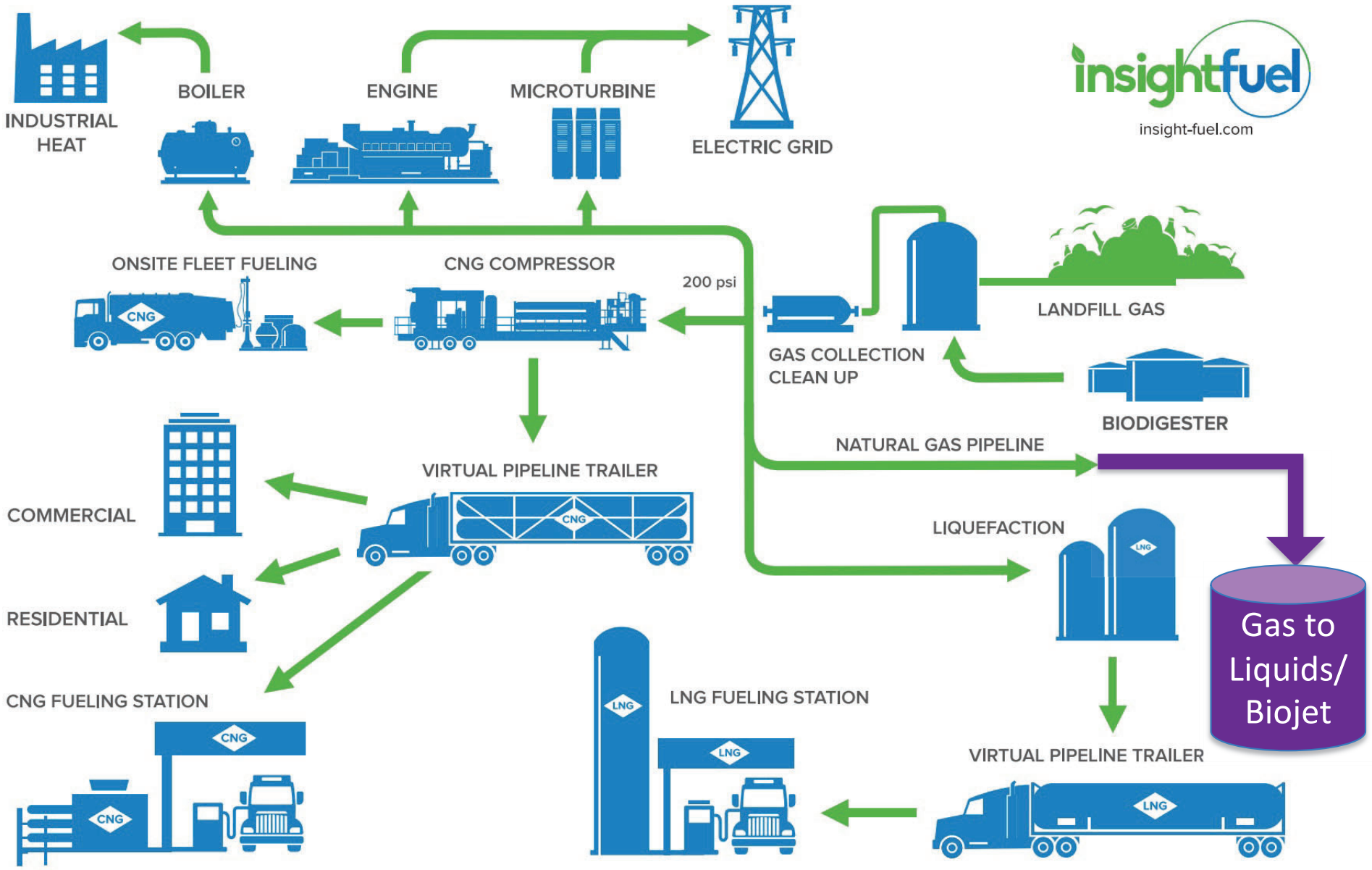
Cleaner burning: RNG is identical to fossil natural gas and is cleaner burning than diesel.

Methane capture and use: Methane has 25 times more global warming potential than CO_2. Wastes that would otherwise be harmful are turned into beneficial use.

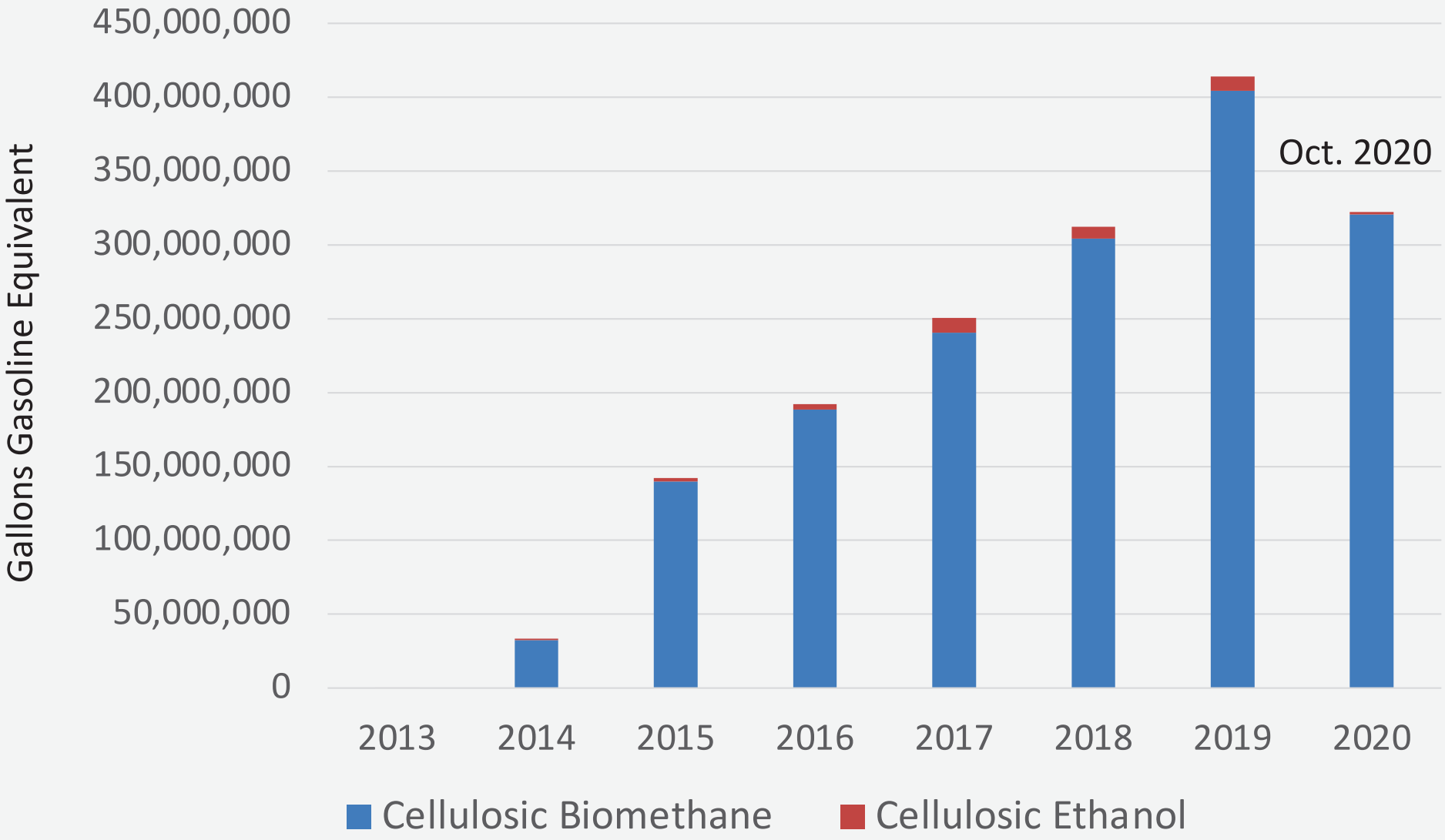
Carbon dioxide capture and storage: The co-produced CO_2 can be captured and sequestered



RNG: The New Paradigm

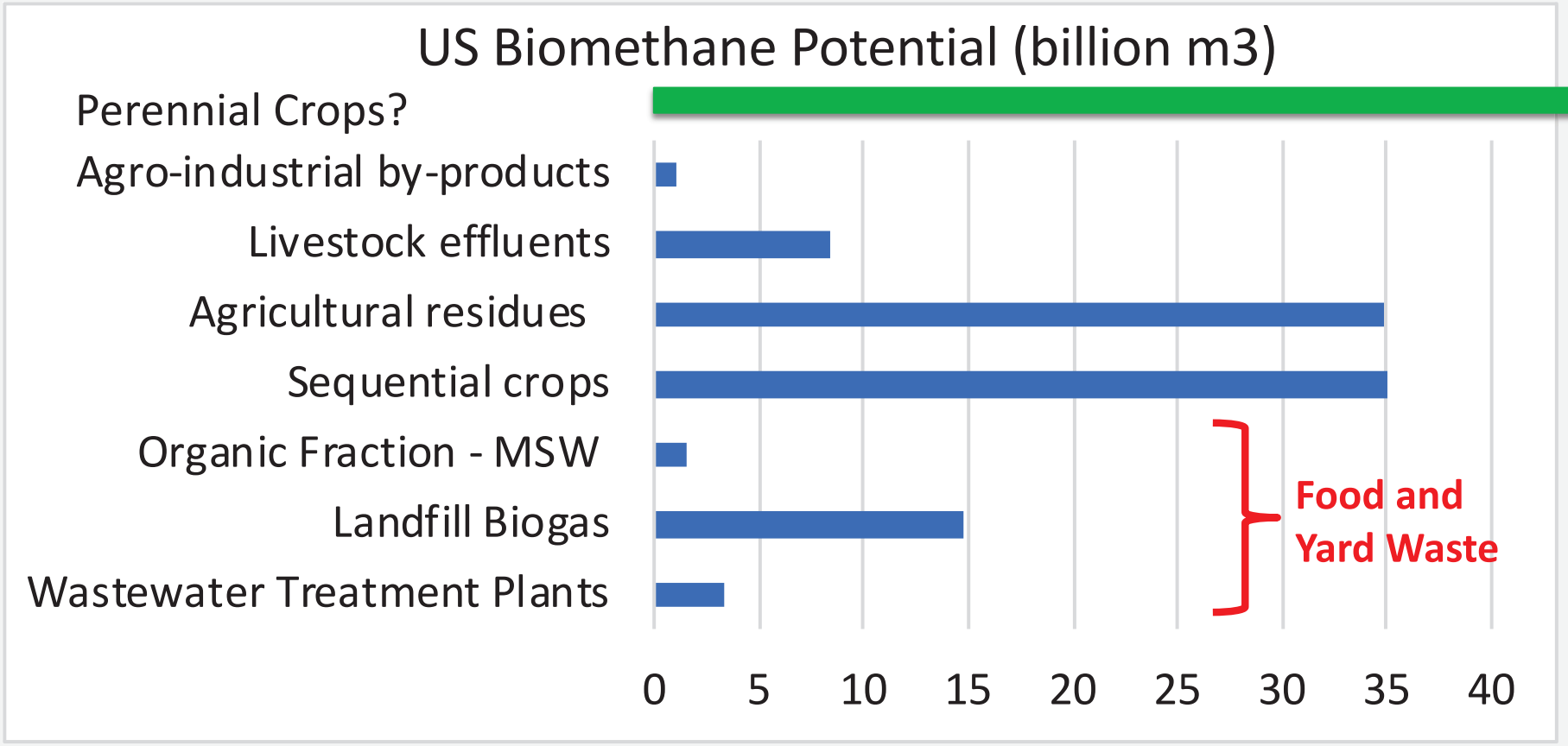


Rapid Growth is Possible



BiogasDoneRight™:

Potential for the United States

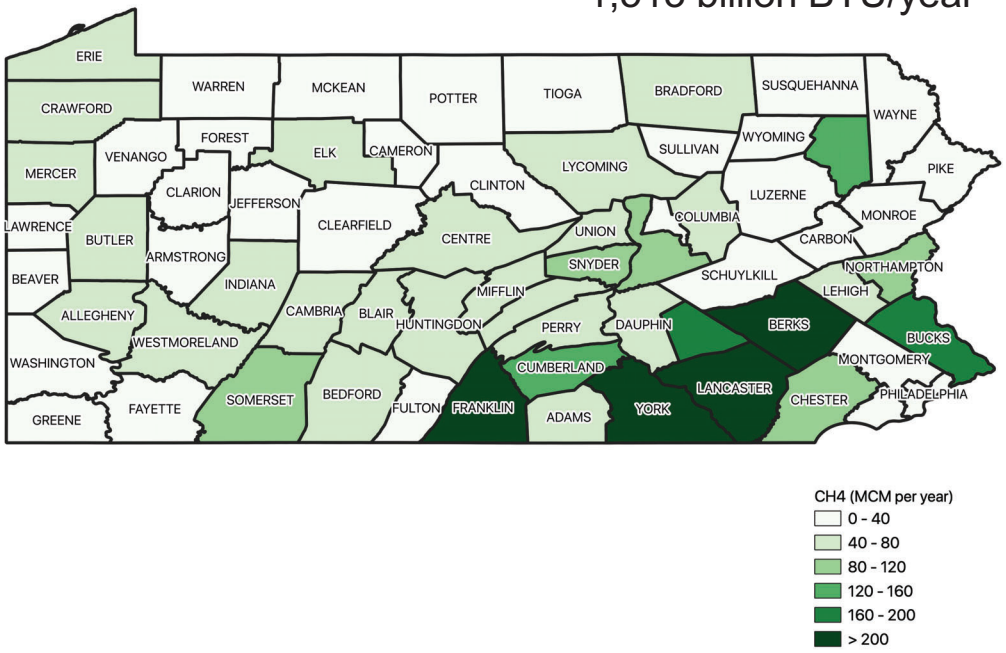


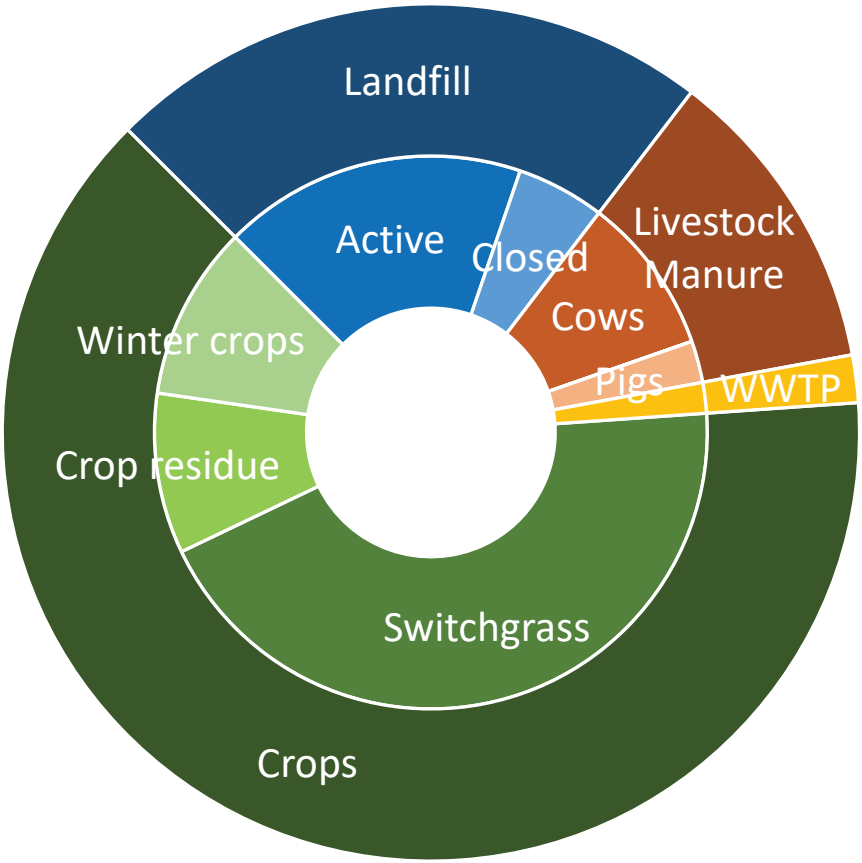
Current Fossil CH_4 (Natural Gas): **756** billion m^3/year
Bio-CH_4 (Natural Natural Gas): **98** billion m^3/year
Fraction of current Natural Gas: **13%** **(Dale et al. 2020)**

Pennsylvania's Renewable Natural Gas Potential

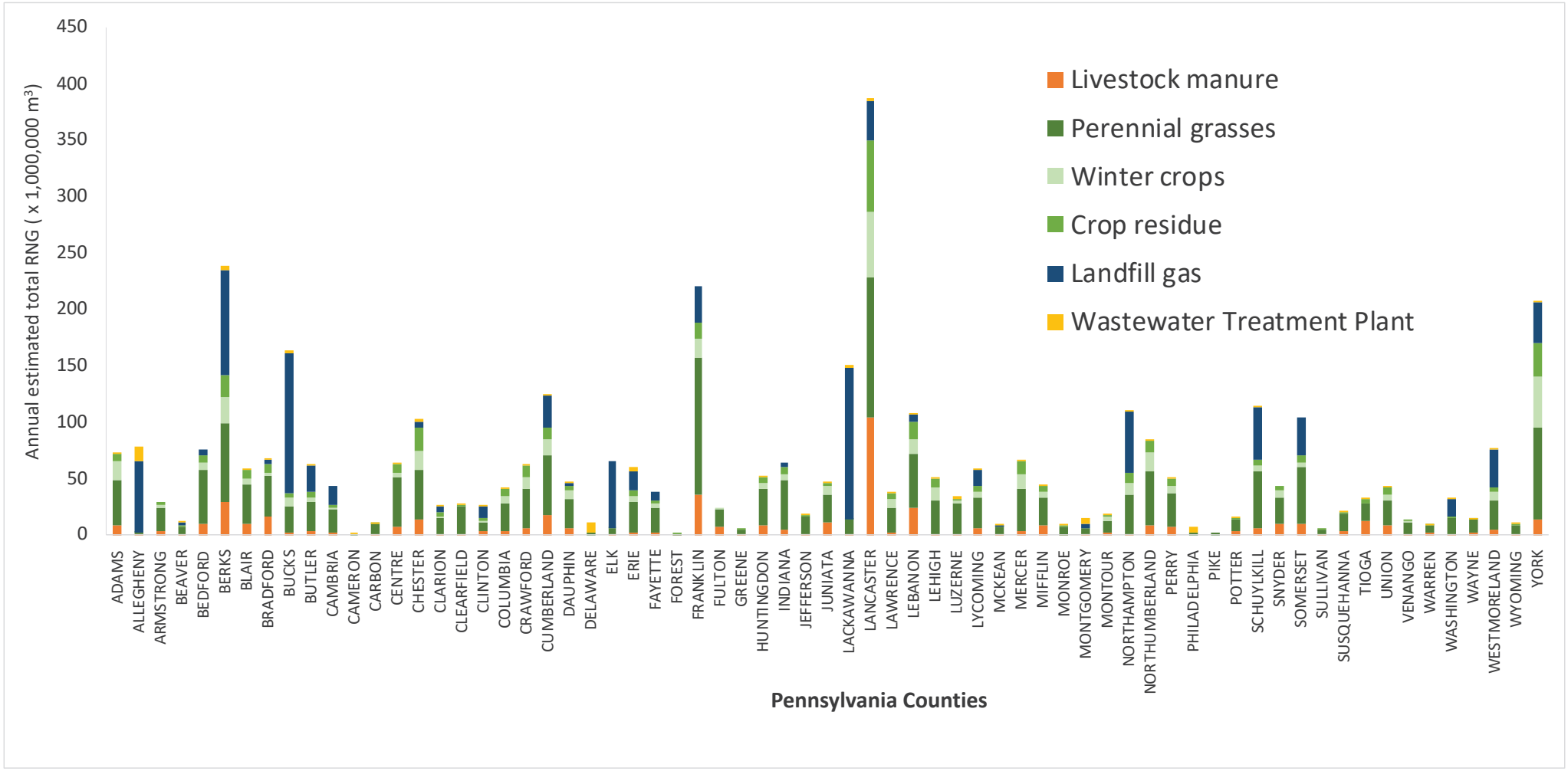
	RNG (mmBTU per year)	RNG (mmBTU per year)
Crops		**91,478,883**
Switchgrass	63,301,222	
Crop residue	13,496,528	
Winter crops	14,681,132	
Landfill		**32,951,146**
Active	25,523,365	
Closed	7,427,781	
Livestock Manure		**16,822,448**
Cows	13,306,620	
Chicken	13,581	
Pigs	3,502,247	
Wastewater Treatment Plant	**2,574,823**	**2,574,823**
Total RNG Potential:		**143,837,300**

2020 PA Natural Gas Demand:
1,513 billion BTU/year





PA Potential RNG Feedstocks by County



Key drivers for Biogas and RNG

- *Renewable Fuel Incentives have shown rapid growth in Renewable Natural Gas is possible.*
- *America and the world are rapidly expanding natural gas infrastructure to produce:*
  - *Dispatchable electricity (peak power, complement solar & wind)*
  - *Transportation via natural gas vehicles*
  - *Chemicals and liquid fuels*
- *Pipelines easily aggregate and distribute Renewable Natural Gas*
- *Growing Biomass Feedstocks can provide waste management and water quality benefits.*

Challenges for Biogas and RNG

- *Avoiding methane leaks!*
- *Keeping digesters warm in the winter*
- *Getting gas to market*
- *Making technology affordable for smaller farms*
- *Simplifying digester management*
- *Digesting lignocellulosic biomass*
- *Generating value-added products*

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science for a changing agriculture

Conclusions

- More than 40% of the climate solution portfolio directly relates to food and agriculture – and that percentage will grow when we get serious about negative emissions
- In the food and agriculture sector many solutions can be market driven and profitable for rural communities
- These solutions have co-benefits for soil health, nutrient management, air and water quality
- Renewable Natural Gas is a growing example of these win-win-win opportunities

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