ONEOK

LANDFILL GAS ENERGY PROJECT

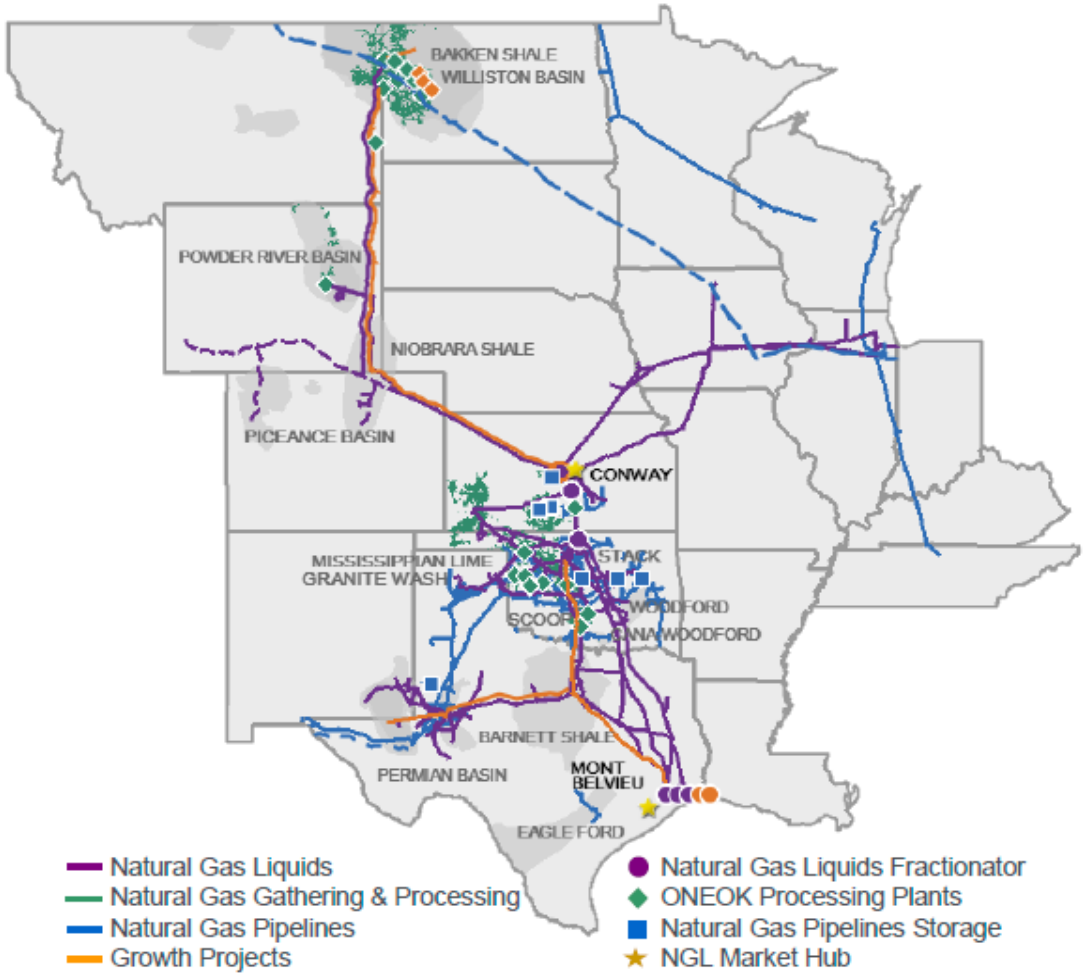
NOVEMBER 6, 2019

Edmond storage — Oklahoma

LANDFILL GAS PROJECT

ONEOK FOOTPRINT

- Approximate 38,000-mile network of pipelines
  - Natural Gas Liquids
  - Natural Gas Gathering and Processing
  - Natural Gas Pipelines
- Provides midstream services to producers, processors, and customers.



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LANDFILL GAS AND EMISSIONS

- **What is Landfill Gas?**
  - Landfill gas (LFG) is generated during the natural process of bacterial decomposition of organic material contained in municipal solid waste (MSW) landfills. A number of factors influence the quantity of gas that a MSW landfill generates and the components of that gas.
    - Type and age of the waste buried in the landfill.
    - Quantity and types of organic compounds in the waste.
    - Moisture content.
    - Temperature of the waste.

- **Methane Emissions from Municipal Solid Waste Landfills**
  - According to the EPA, landfills are the third largest source of methane emissions in the United States generated by human activity.
  - Capturing this methane for reuse is a great opportunity to reduce methane emissions and also capitalizes on a significant energy source.

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LANDFILL GAS LIFECYCLE

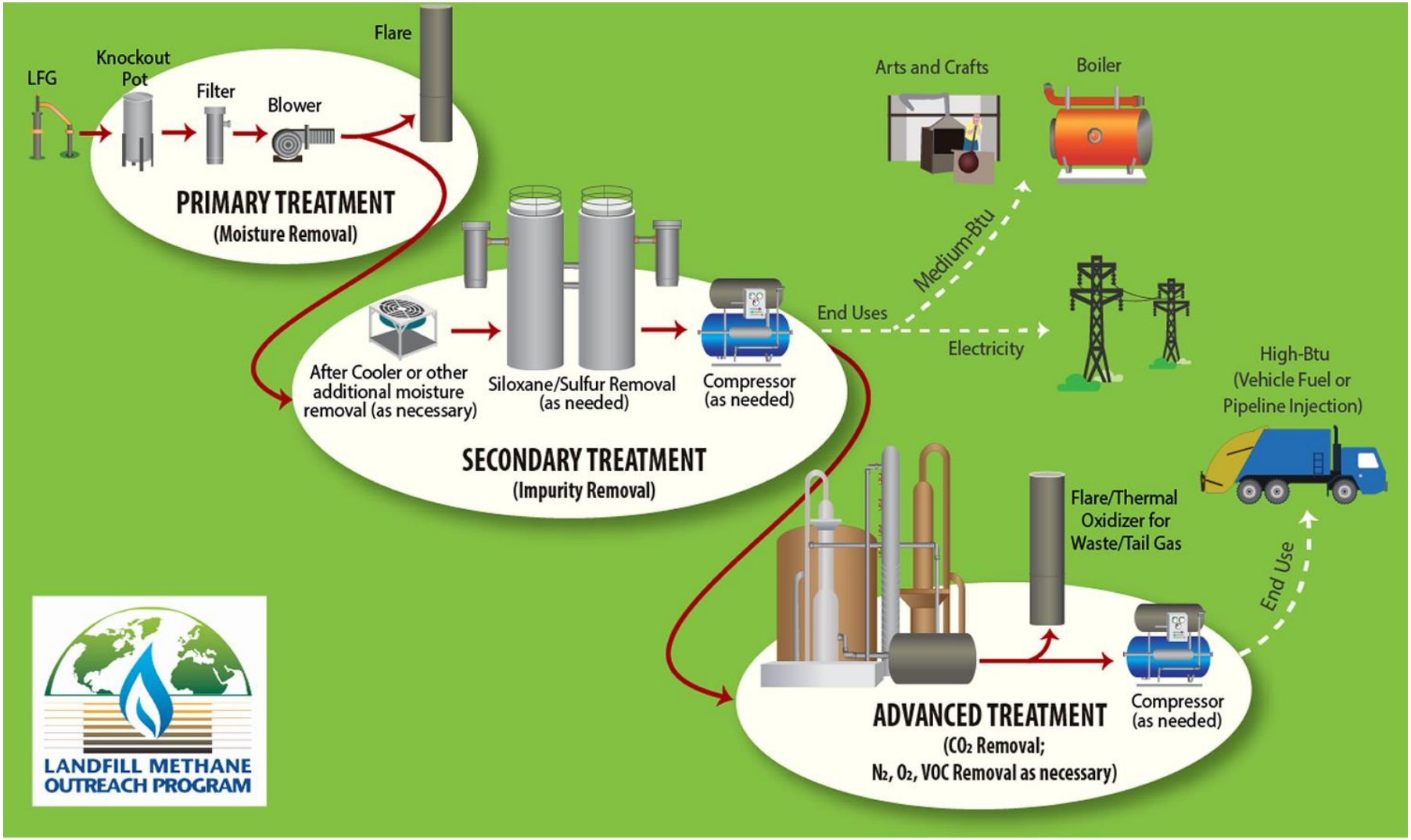

Figure 1: LFG Collection and Processing Illustration

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PROJECT OVERVIEW

- **Project Players:**
  - Oklahoma City Landfill
  - Third-party gathering and processing company
  - ONEOK (ONEOK Gas Transportation, L.L.C.)

- **Project Scope:**
  - August 2018 - Oklahoma City landfill gathers biogas that is processed and transported by third party to ONEOK natural gas pipeline
  - The system averaged **1,330 MCFD** in 2018
  - Total Methane Emission Reduction of **165,000 MCF** in 2018

For Reference: The average U.S. household consumes between 150-200 scfd.

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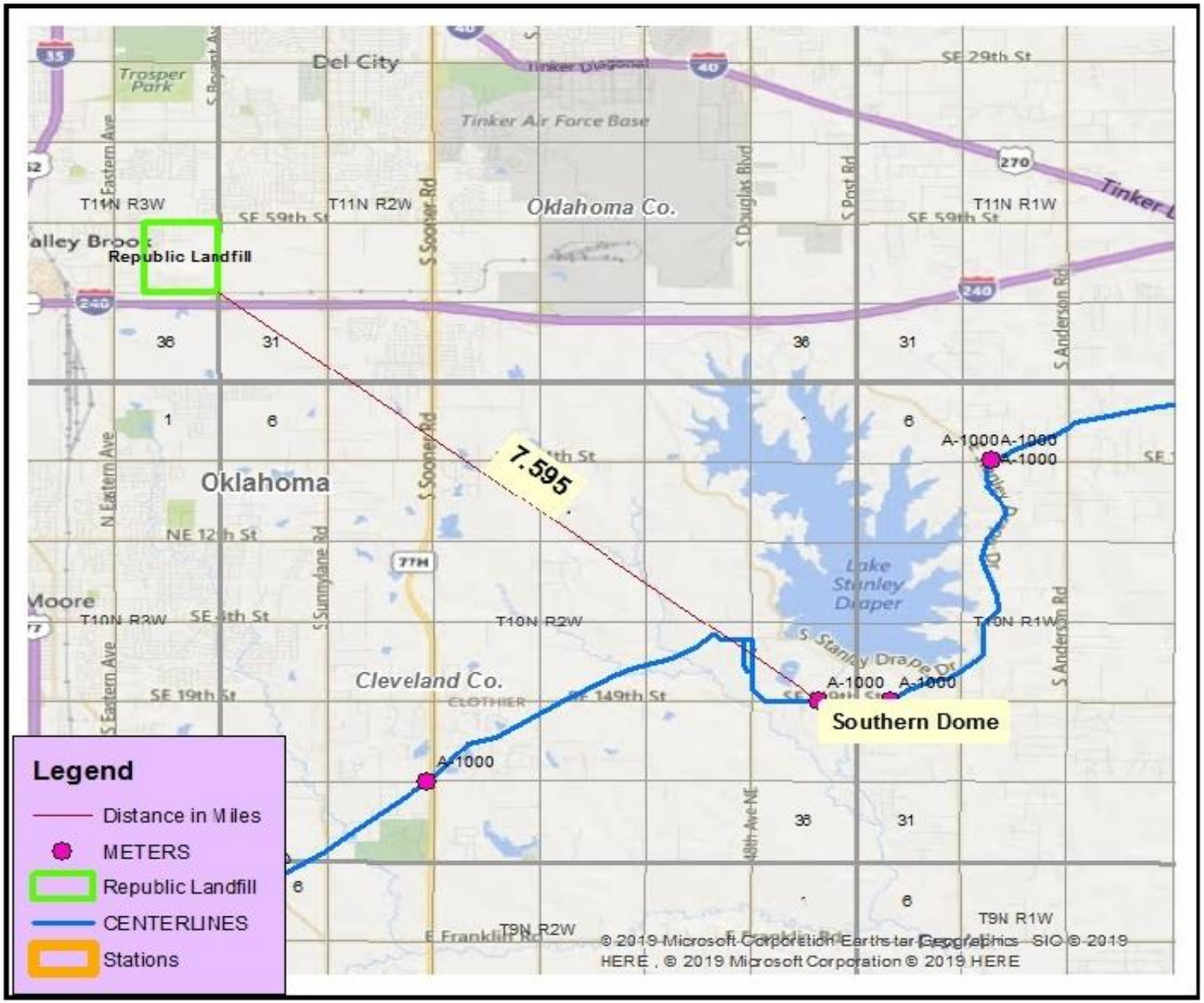
ONEOK Landfill Project



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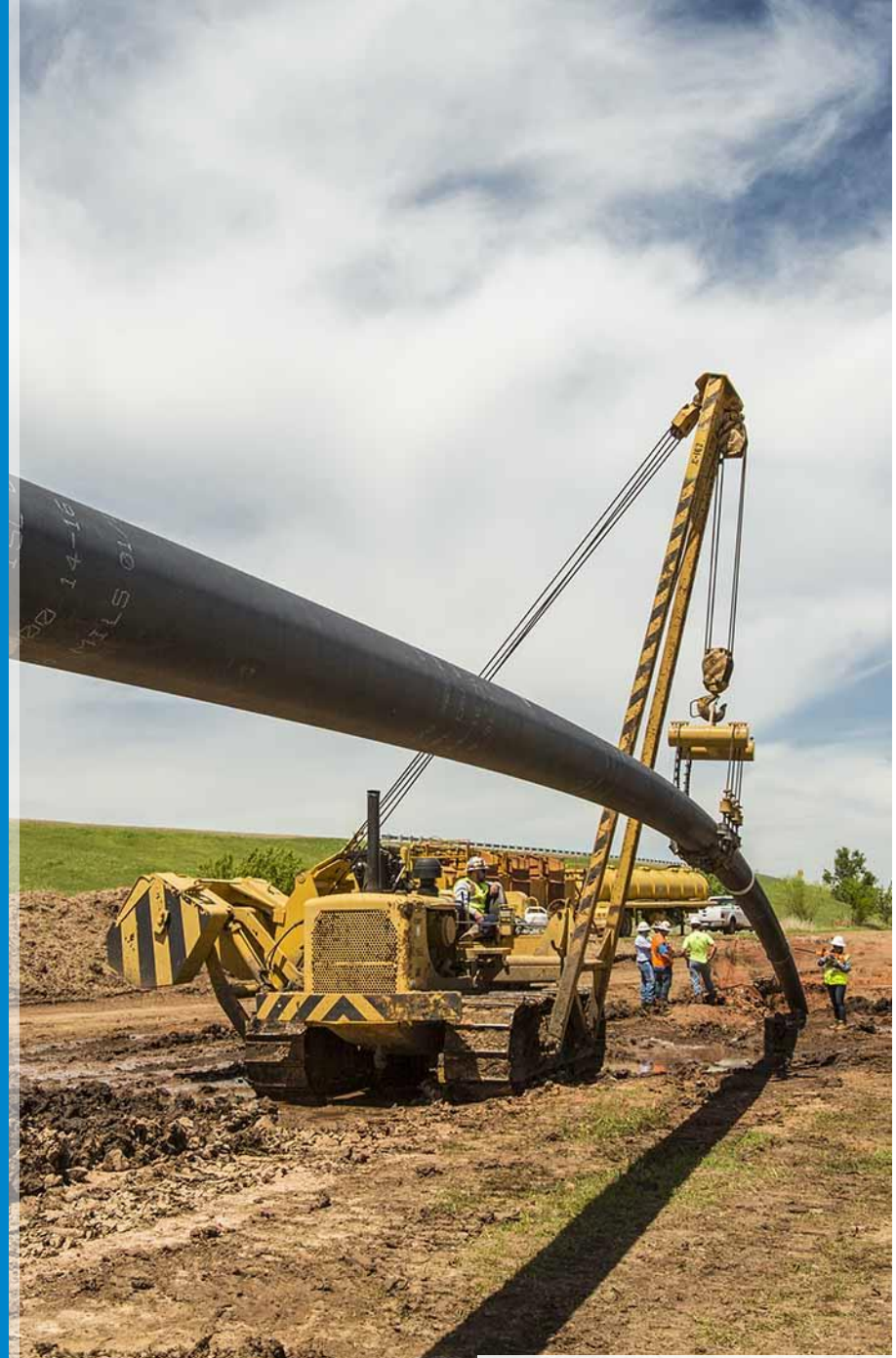
PROJECT GAS QUALITY CHALLENGES

- **LFG Composition (approximate):**
  - 50% methane
  - 50% CO2
  - Less than 1% non-methane organic compounds
  - Trace amounts of organic compounds

- **General Pipeline Gas Composition**
  - 97% methane;
  - Less than 1% CO2
  - Less than 1% non-methane organic compounds
  - Trace amounts of organic compounds

- **Btu Value**
  - BTUs are traditionally low for landfill renewable natural gas.
  - Minimum BTU 975 (OGT)
  - Maximum BTU 1080 (OGT)

- **Impurities or Unknowns**
  - Sulfur content
  - Unknowns



Mustang Pipeline — Oklahoma

LANDFILL GAS PROJECT

PROJECT ECONOMICS

- **Capital Cost**
  - Proximity
  - Infrastructure
- **Operation and Maintenance Costs**
  - O&M costs must be considered when evaluating project economics
- **Volumes**
  - Reliable volumes for ongoing operations

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LANDFILL GAS PROJECT

OTHER ONEOK RENEWABLE GAS PROJECTS

- **Other RNG Projects at ONEOK**
  - Dodge County, Wisconsin – Air Liquide Landfill Gas Project
  - Hilbert, Wisconsin – Holsum Dairy Biogas Project

- **Looking Ahead at RNG Projects**
  - ONEOK has been approached with more biogas projects
  - Innovative technology is a key contributor to making these projects more viable
  - ONEOK continues to learn how to make these projects more efficient and economically feasible

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Arbuckle II Pipeline — Oklahoma

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PRESENTATION SOURCES

- Epa.gov. (2019). *Landfill Methane Outreach Program*. [online] Available at: https://www.epa.gov/lmop/frequent-questions-about-landfill-gas [Accessed 16 Oct. 2019].
- EPA.gov (April 2017). LFG Energy Project Development Handbook [online pdf]. Retrieved from https://www.epa.gov/sites/production/files/2016-11/documents/pdh_full.pdf

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