OVERVIEW OF SHALE GAS EXPLORATION AND ANALYTICAL METHODS FOR CHARACTERIZATION OF SHALE GAS

2019 NEMC CONFERENCE,

JACKSONVILLE, FL

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Agenda

- Introduction
- Status of O & G Exploration Processes
- Products Extracted and Separations
- Production in the US Shale Plays
- Exports
- Analytical Methods for Shale Gas Analysis
- Additional Analysis due to Management of Flow Back Water
- Flaring and Capture of NG and its Impacts on Emissions
- Summary

Introduction

- Technology has significantly improved since 2009 in Hydraulic Fracturing
- O&G export restrictions have been removed in the US
- Crude oil export terminals have sprung up along the Gulf Coast from Corpus Christi to New Orleans
- LNG plants have proliferated along the gulf coast to convert Natural Gas to LNG for exports
- Pipeline capacity for transport is lacking (for both crude and natural gas)
- Imports of crude oil have fallen to a 30 year low (according to EIA)

Status of O & G Exploration Processes

- Stacked wells
- Multiple laterals
- Longer lateral lengths (from the 2.5 miles to 5 miles)
- All from a single well pad
- Traditional wells are also undergoing Hydraulic Fracturing
- Drilling techniques are being refined with 3D drilling technology (Halliburton)
- **All of the factors above have increased production and dropped the per barrel cost of harvesting our natural resources.**

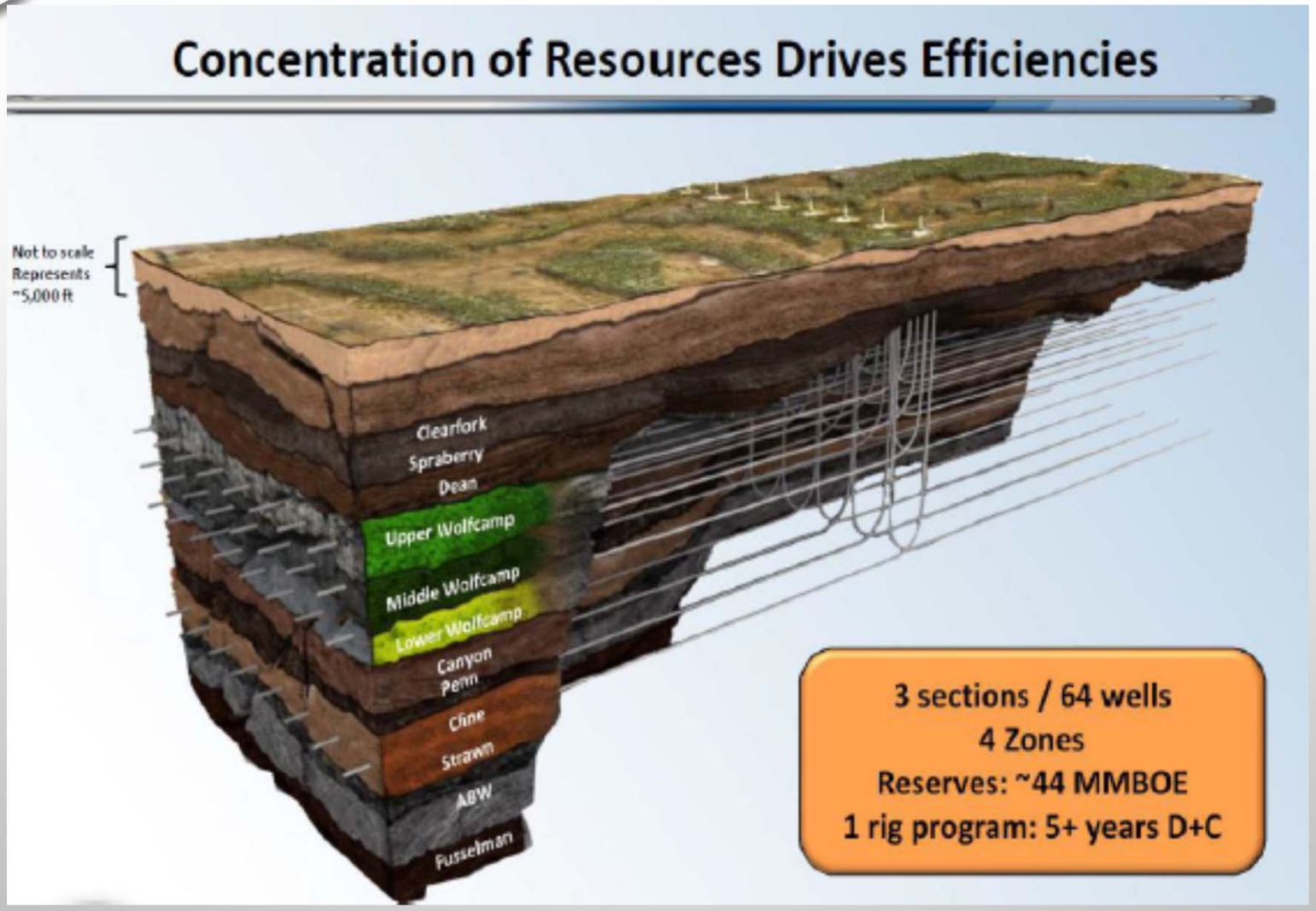


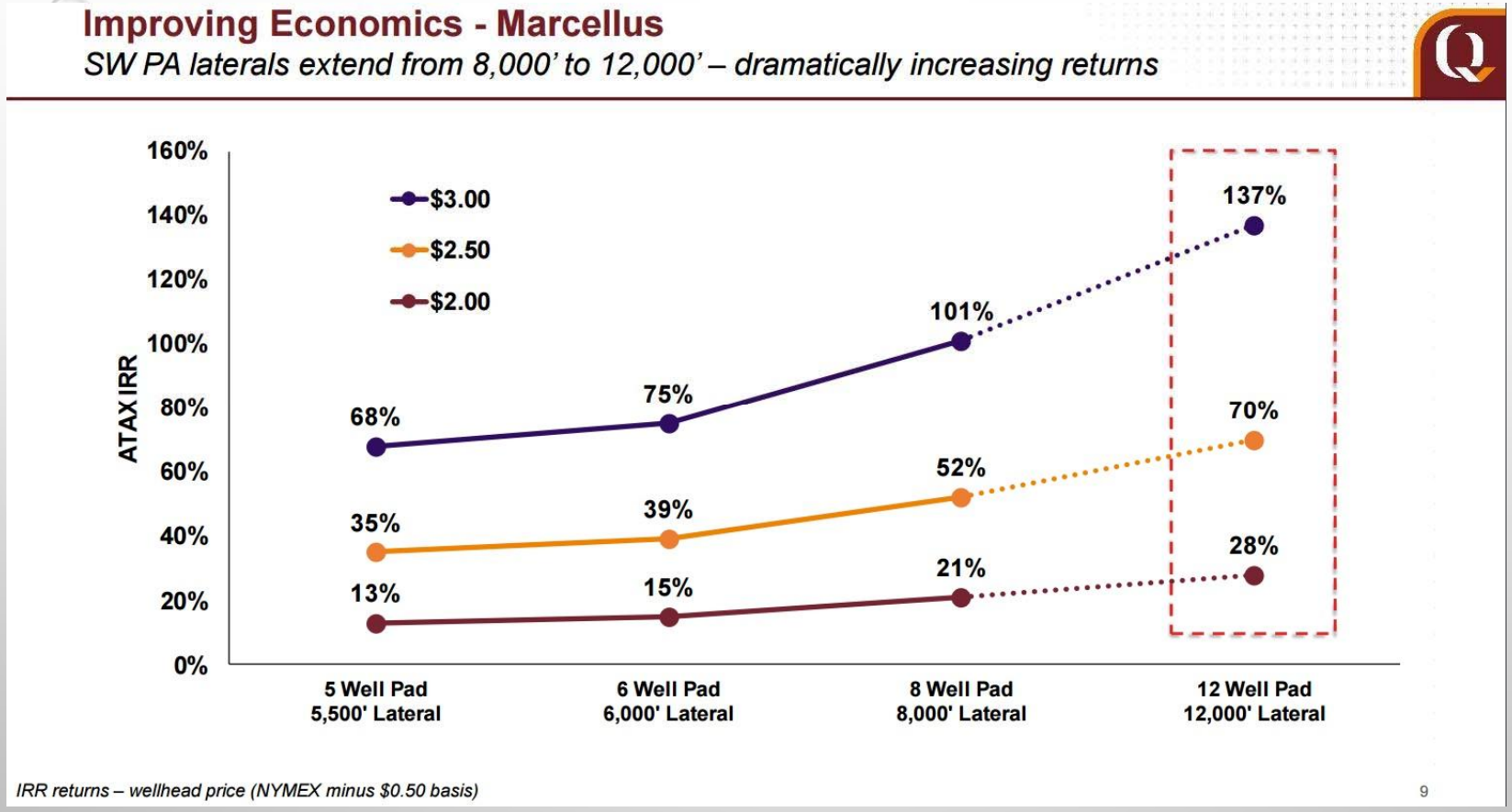
Image: Weatherford

Status of O & G Exploration Processes

Multiple laterals and longer
Distances of the laterals

Image: Halliburton

Status of O & G Exploration Processes



Source: EQT Corporation 2017

Products Extracted and Separations

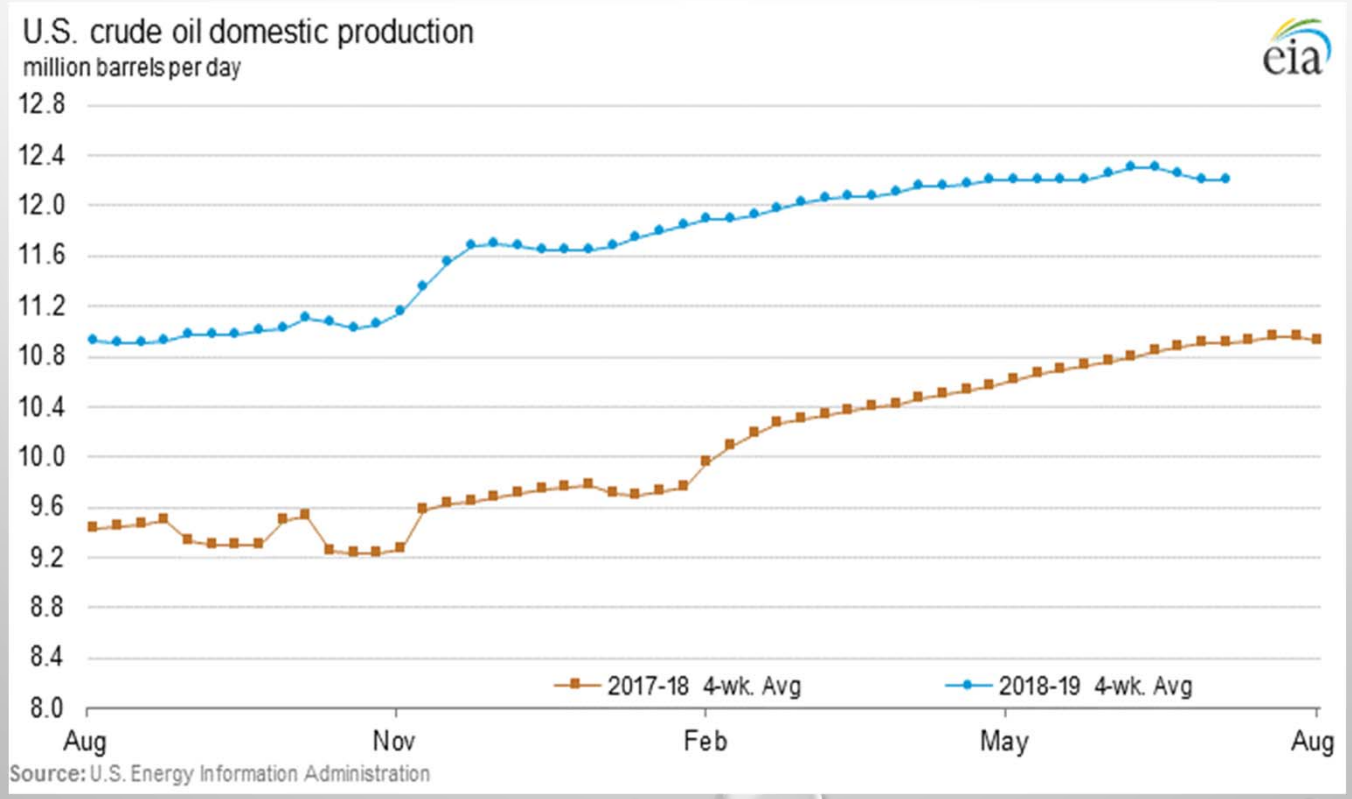
- In crude oil formations – Crude Oil, Water, Natural Gas
- In some formations – Crude Oil, Water, Natural Gas and Liquids
- Crude Oil is separated from the water and natural gas
- Water will be knocked out and Natural Gas will be sent through pipelines or flared (will be discussed later in the emissions slide)
- Additionally, some formations will have H2S. (huge safety issue)
- H2S must be removed at the well head in order to safely handle crude oil through custody transfer, transport and refining operations
- Typically additives such as amines tie down the H2S from crude oil

Products Extracted and Separations

- In Natural Gas Formations – Natural Gas, Water and Condensates
- Water and Liquids will be separated from the Natural Gas
- Pipeline capacity is an issue currently to capture all the natural gas

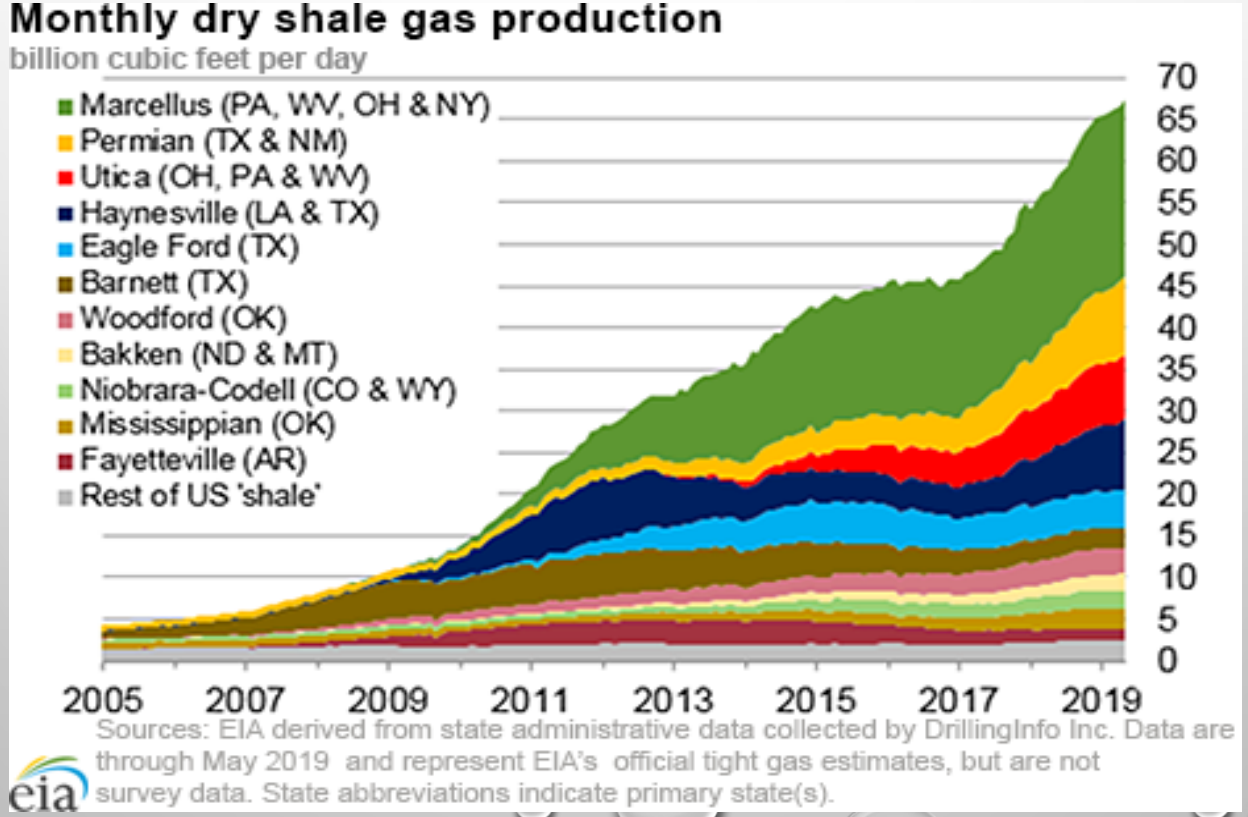
Production in the US Shale Plays

- Crude Oil Production (exceeded 12.2 million barrels per day in April 2019)
- Permian is the largest producer of Crude Oil in the US (~ 5 MBPD)



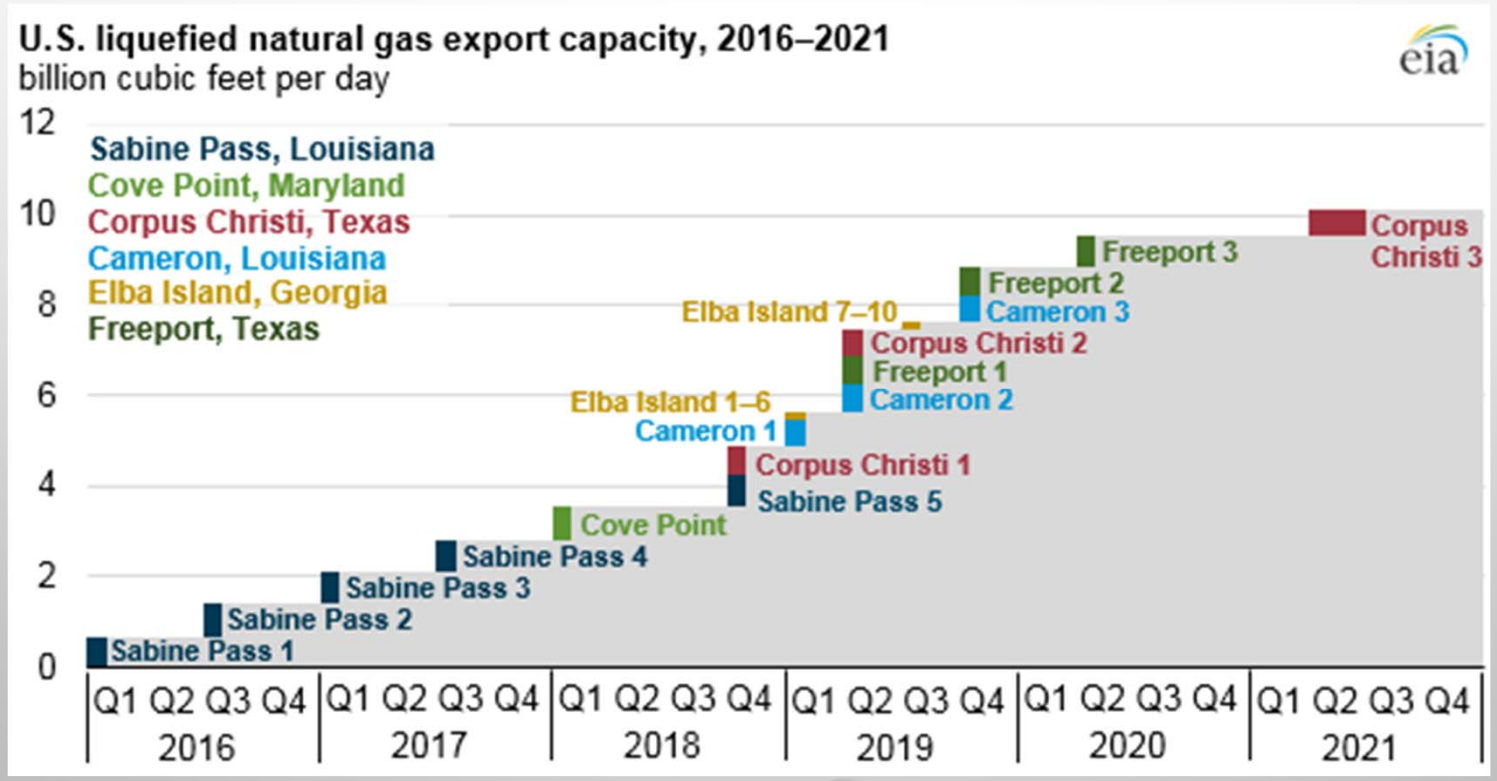
Production in the US Shale Plays

- Natural Gas Production
- Permian is the largest producer of Crude Oil and Natural Gas in the US



Exports

- Current crude oil exports are at 2.8 million barrels per day (MBPD)
- Current LNG export projections are at:



Analytical Methods for Shale Gas Analysis

- GPA 2261 – C1 through C6+) and physical properties like BTU, and additional gases such as H2S, H2, CO2, N2, O2…
- GPA 2286 – C1 through C10 + and individual components including BTEX (typically called extended analysis)
- Typically these are pressurized samples collected in 300 ml cylinders
- ASTM D7833 also measures natural gas parameters and is known as refinery gas analysis method (lot of labs still have not converted to this method and keep referring to ASTM D1945/1946 which are outdated methods)
- Instrumentation – GC's and Micro GC's

Analytical Methods for Shale Gas Analysis

- RSK 175 SOP and modifications
- PA DEP methods – 3686 and 9243
- ASTM 8028-17
- **Coming soon - method for Dissolved Gas Analysis based on the MSC study.**

Additional Analysis due to Management of Flow Back Water

- Next presentation by David Gratson of Environmental Standards, Inc.

Flaring and Capture of NG and its Impacts on Emissions

- Reduced impacts to emissions have been achieved due to use of Natural gas from Shale plays in the manufacturing and drilling industry
- However, those savings are being erased by flaring of Natural Gas
- Lack of Pipeline capacity to transport the natural produced directly or by crude oil production
- Loss of revenue from non use due to lack of infrastructure in the largest producing shale plays
- Natural Gas is replacing coal usage and hence cleaner air
- The petrochemical industry is benefitting from natural gas use and competing in the international markets with US made products

Summary

- Less imports of both Natural Gas and Crude Oil
- Exports are proliferating
- Need to reduce emissions by capture of Natural Gas
- Pipeline infrastructure needs to be implemented in the US
- All agencies must work together to enhance our pipeline infrastructure with rapid approvals in order to reduce emissions
- **MSC validated dissolved gas method will soon become method of choice for industry !!!**

References

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THANK YOU !!!!