

CARBONYL EMISSIONS FROM WELL SITE OIL AND GAS EQUIPMENT

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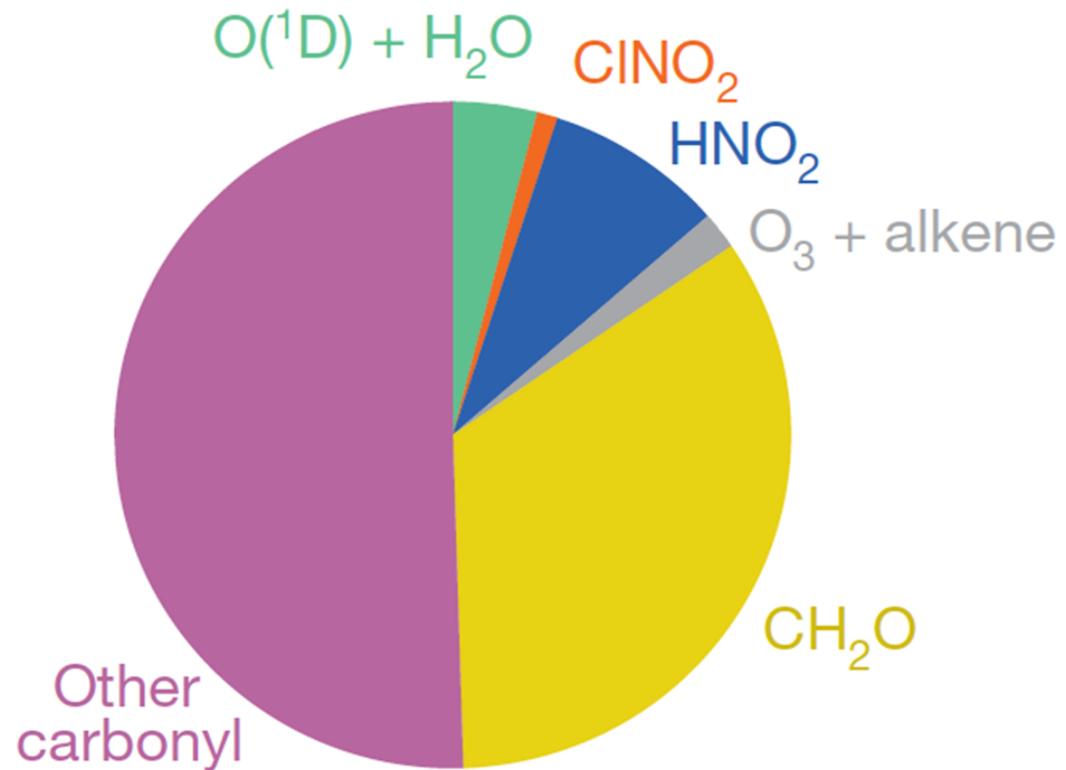


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Ozone Production Requires VOC, NO_x, and Radicals

- Ozone production is catalyzed by radicals
- Carbonyl photolysis is the most abundant radical source during Uintah Basin winters

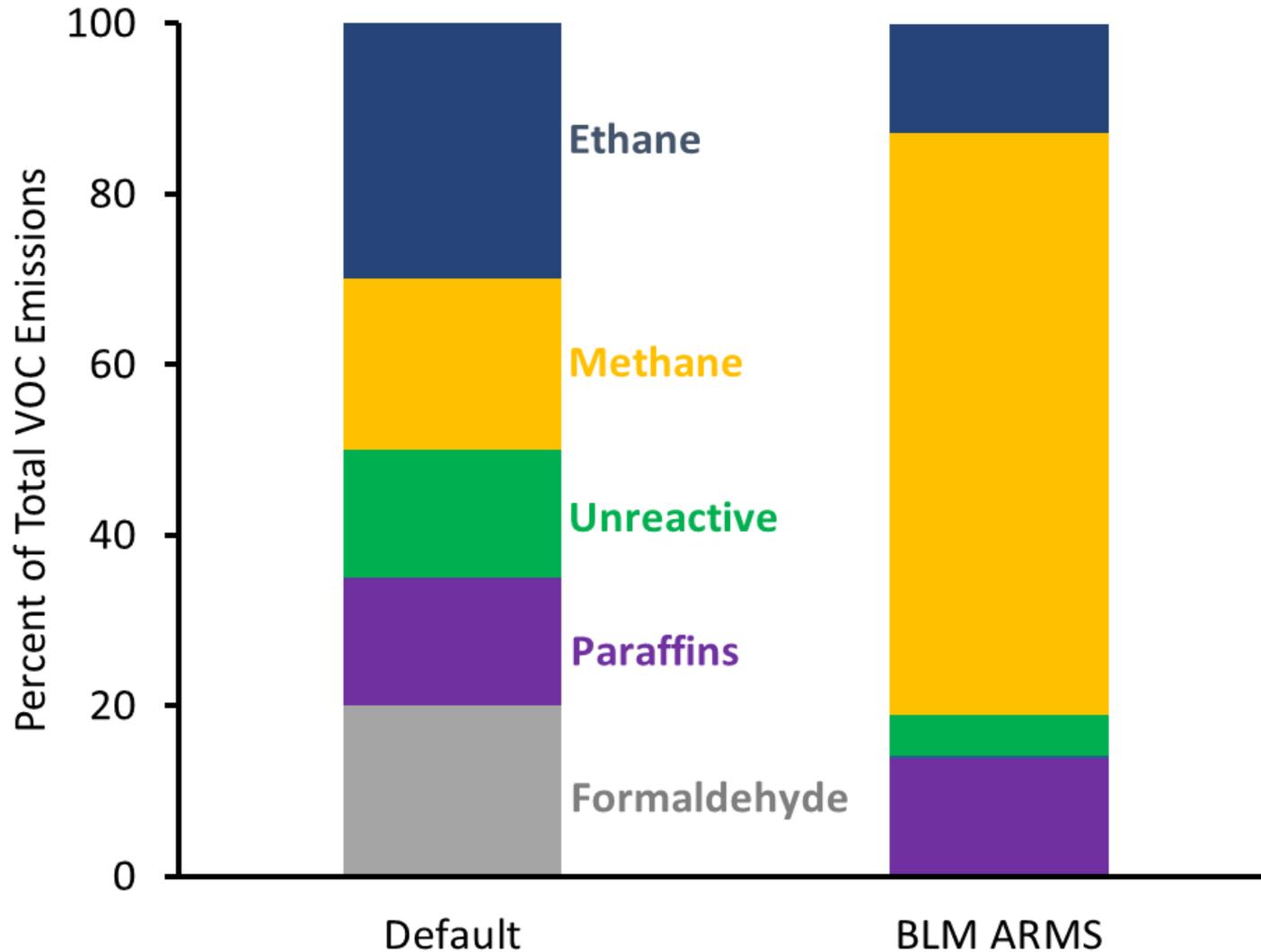


Carbonyls Can Come From Many Sources

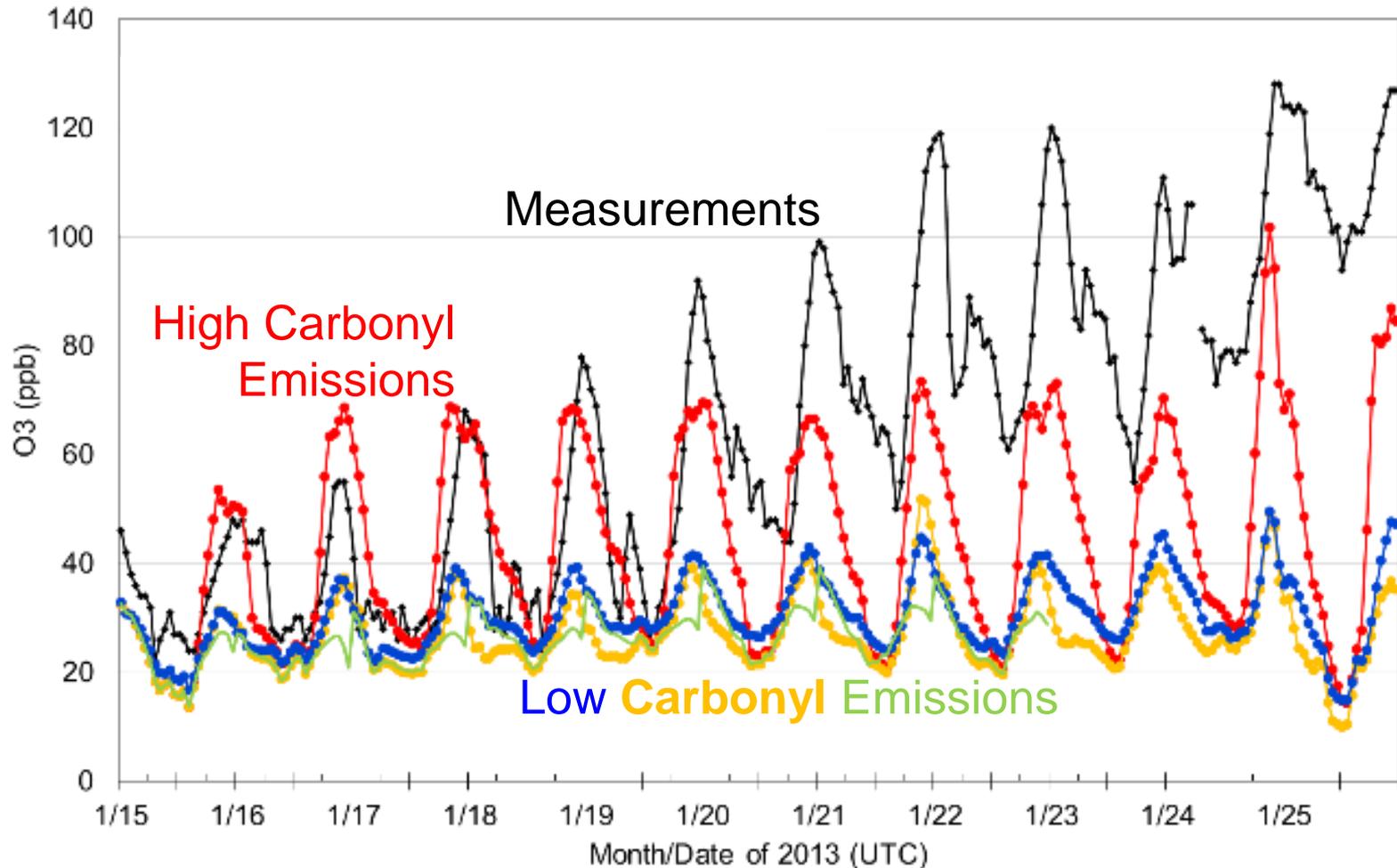
- 1. Primary emissions as part of combustion exhaust**
- 2. Primary non-combustion emissions**
- 3. Secondary formation in the atmosphere**

We Have Little Reliable Information About Carbonyl Emission Sources

Artificial Lift Engine VOC Emissions Profiles

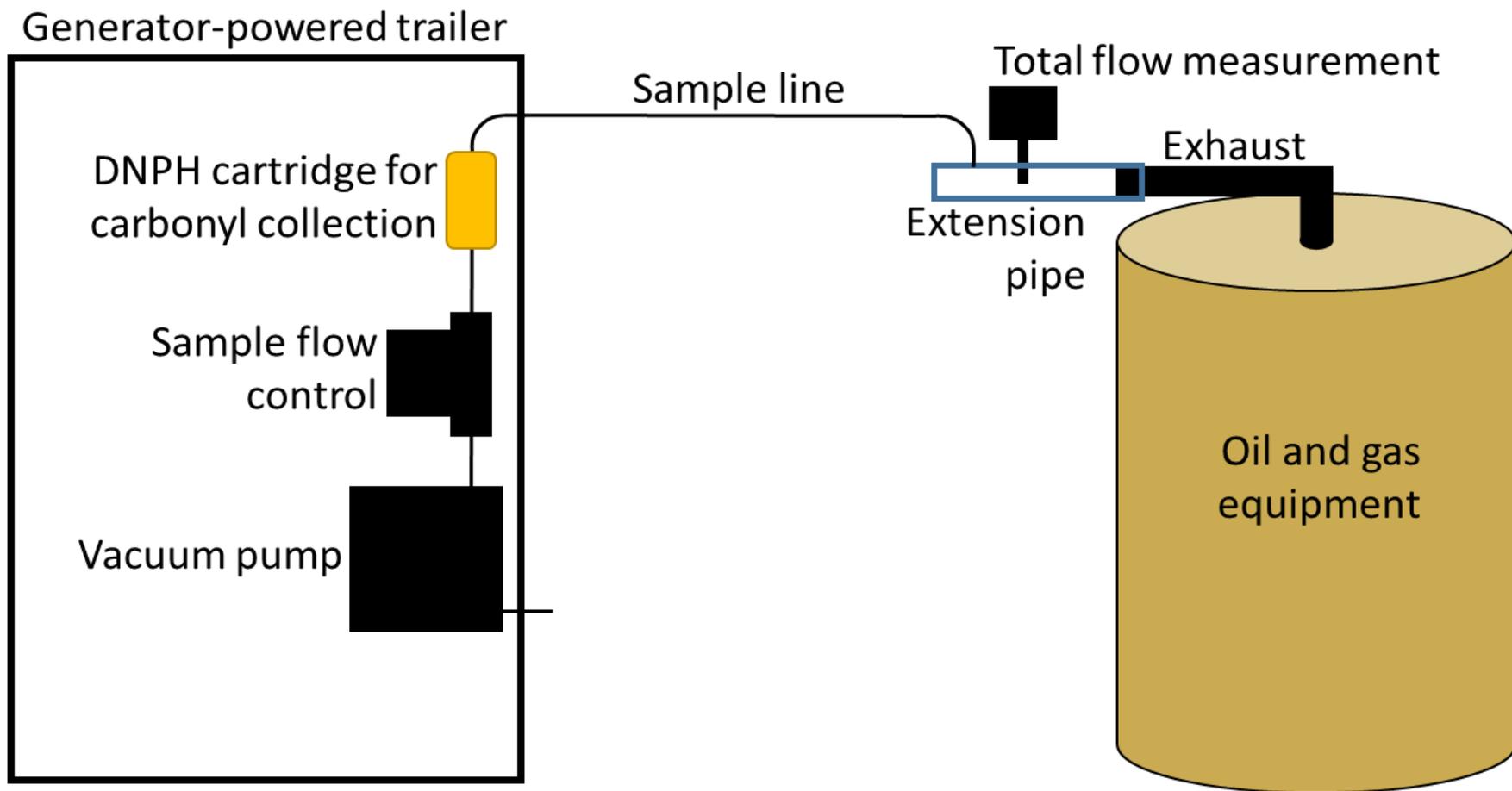


Ozone Production in Photochemical Models Requires High Carbonyl Emissions

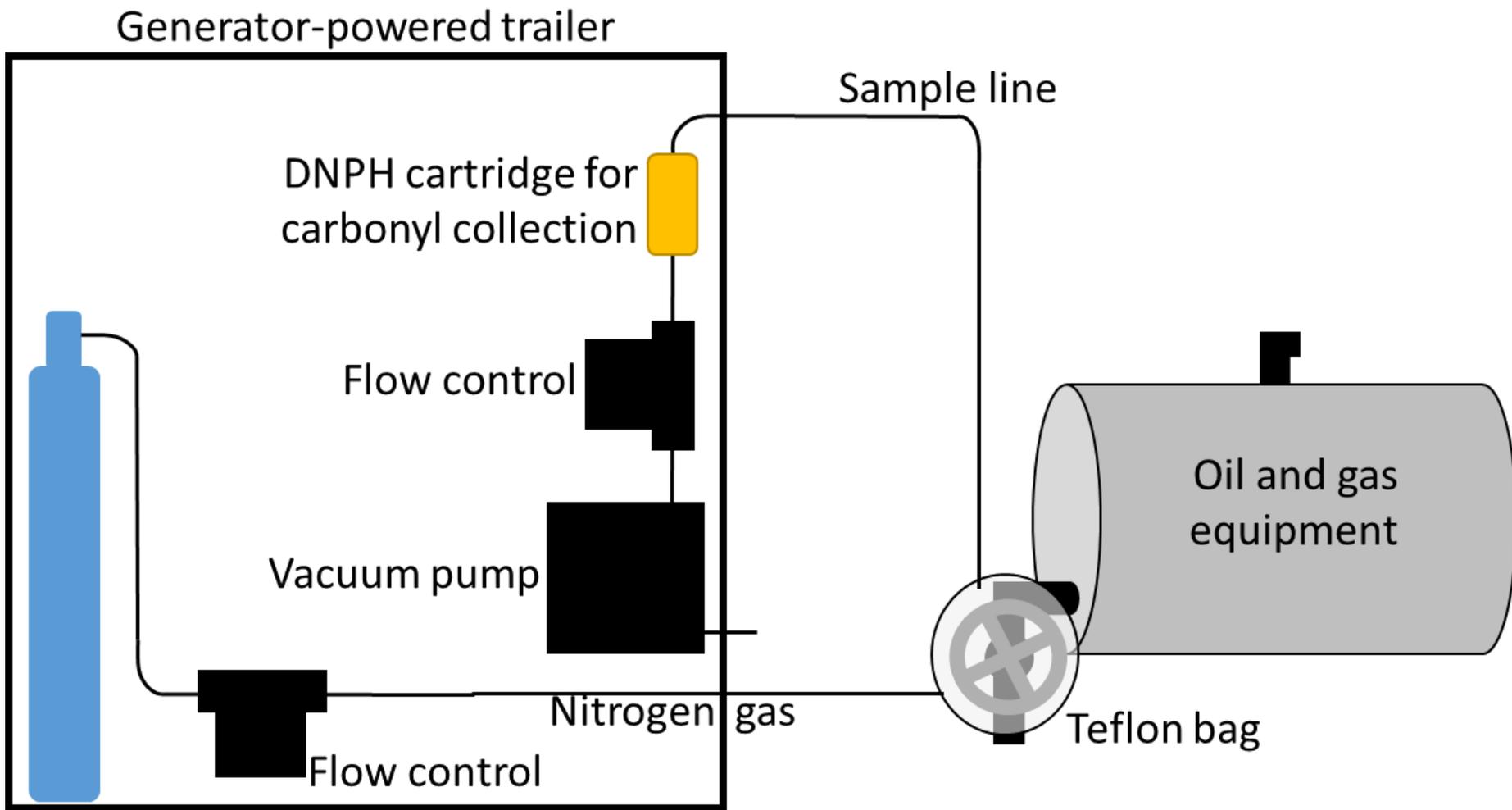


- **Emissions controls that target carbonyls could be extremely effective**

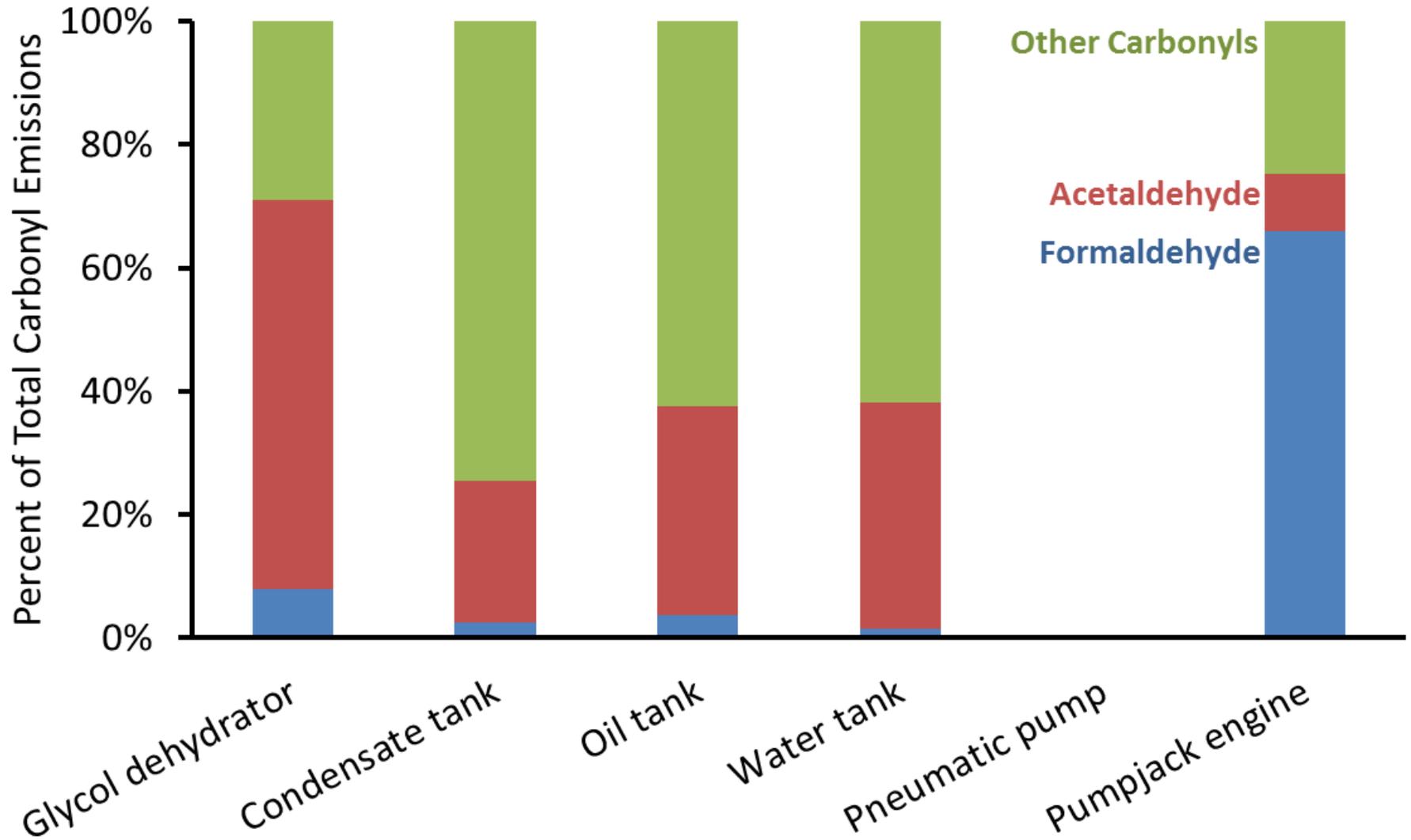
Direct Measurements of Carbonyl Emissions from Oil and Gas Sources Are Needed



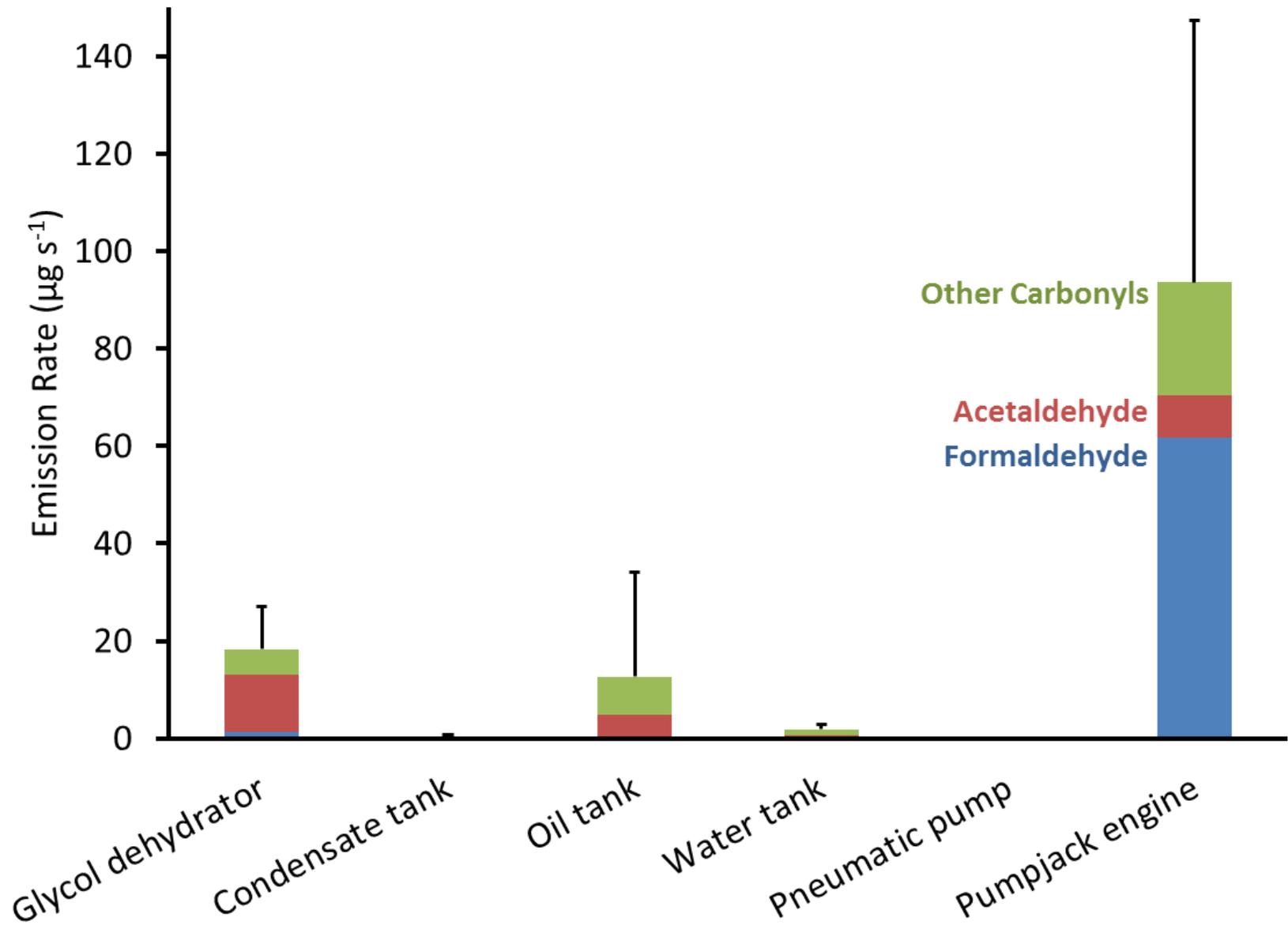
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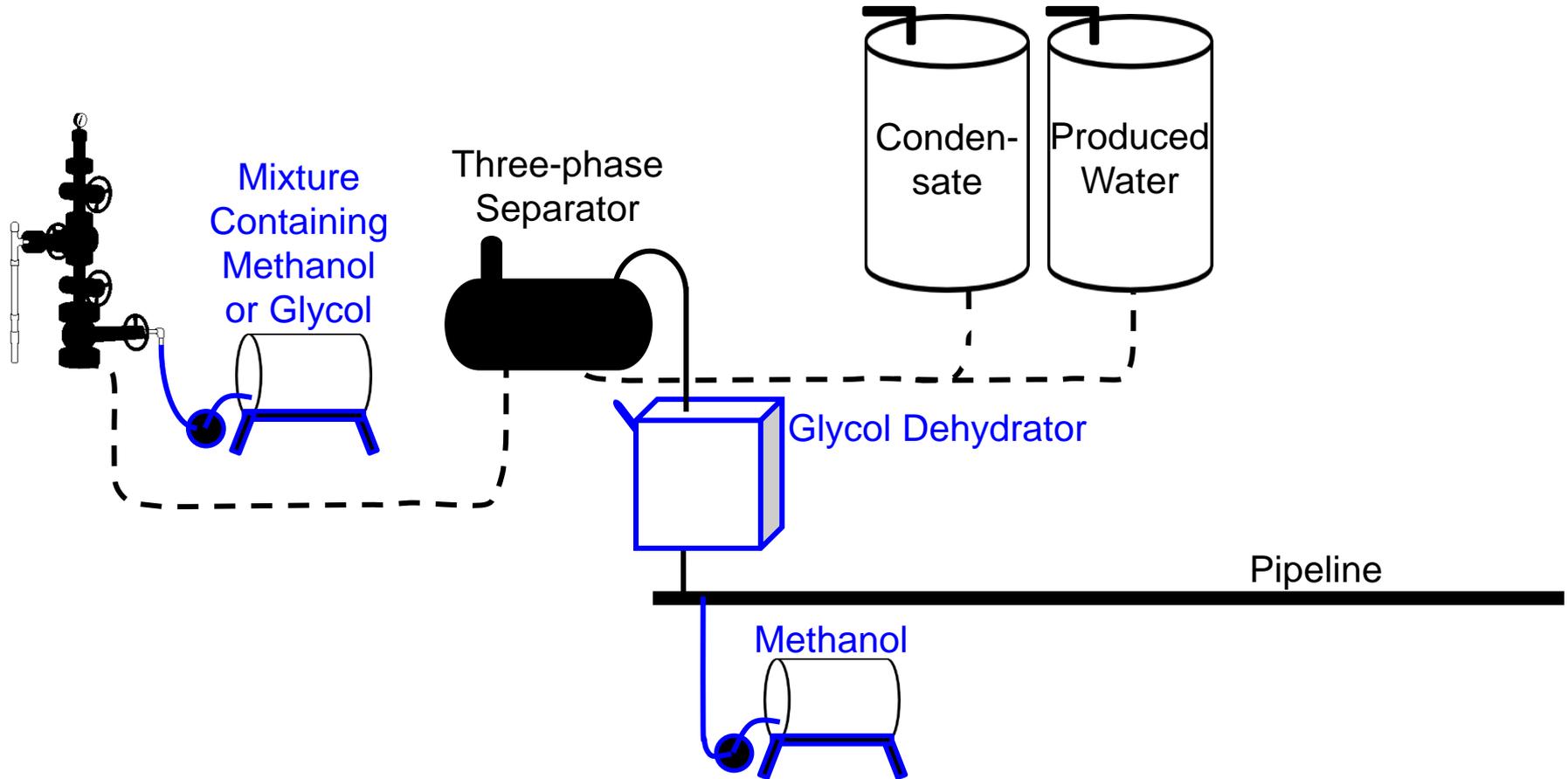
Well-Site Sources Emit Different Carbonyl Compounds



Carbonyl Emissions Were Detected From Many Well-Site Sources

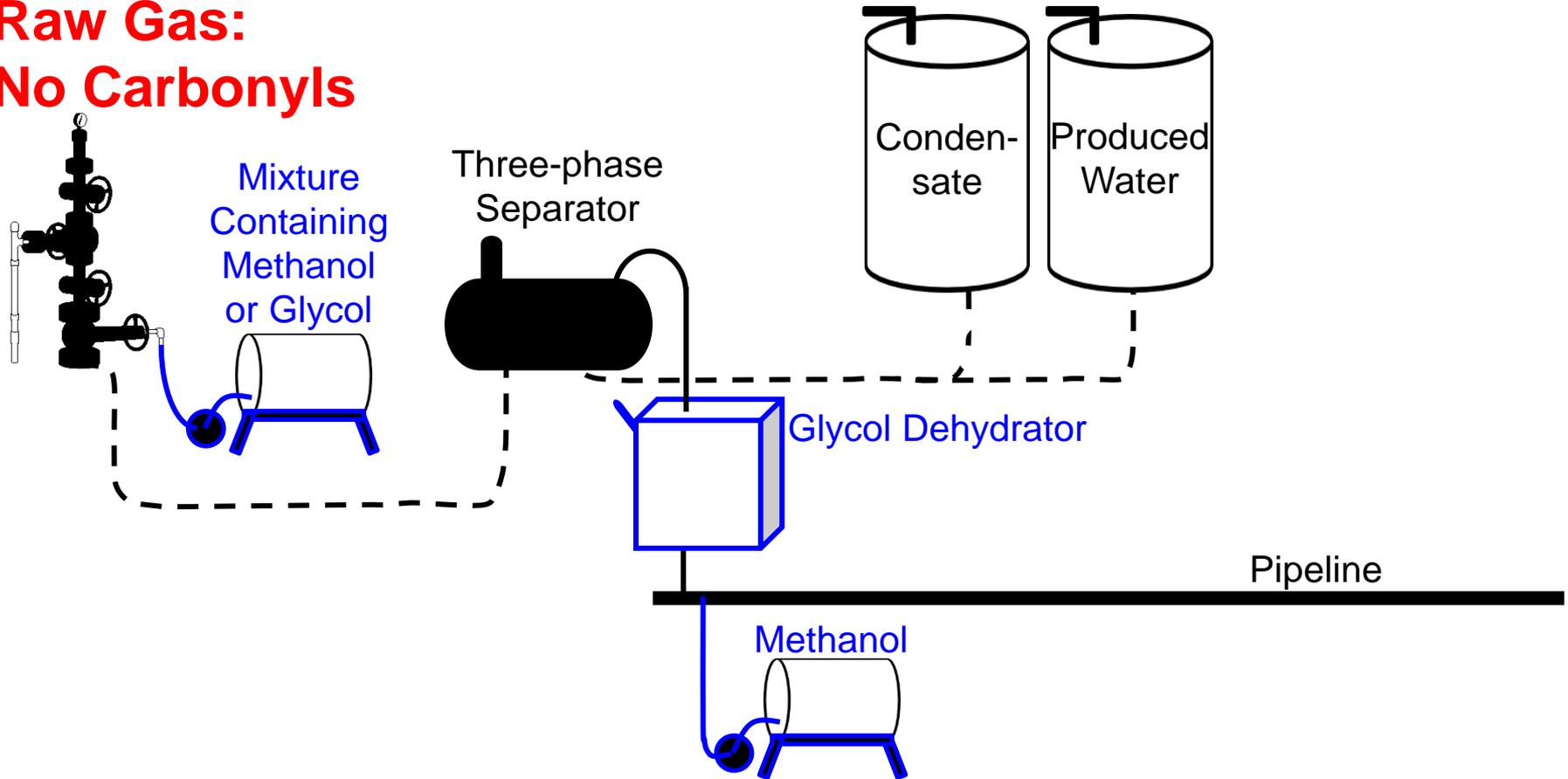


Carbonyls Are Generated By Non-combustion Processes



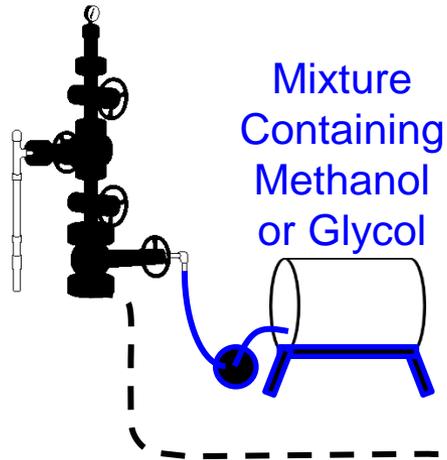
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**Raw Gas:
No Carbonyls**



Carbonyls Are Generated During Non-combustion Processes

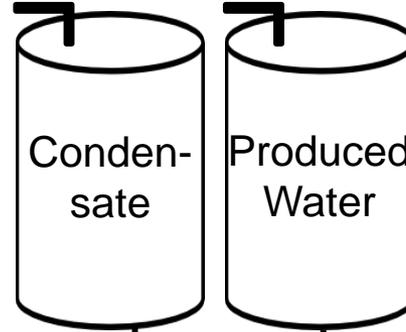
**Raw Gas:
No Emissions**



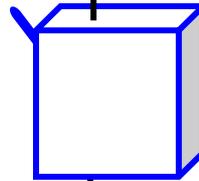
Three-phase Separator



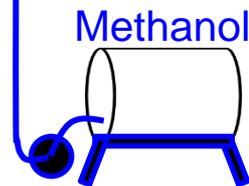
**Liquid Storage Tanks:
0-30 $\mu\text{g s}^{-1}$**



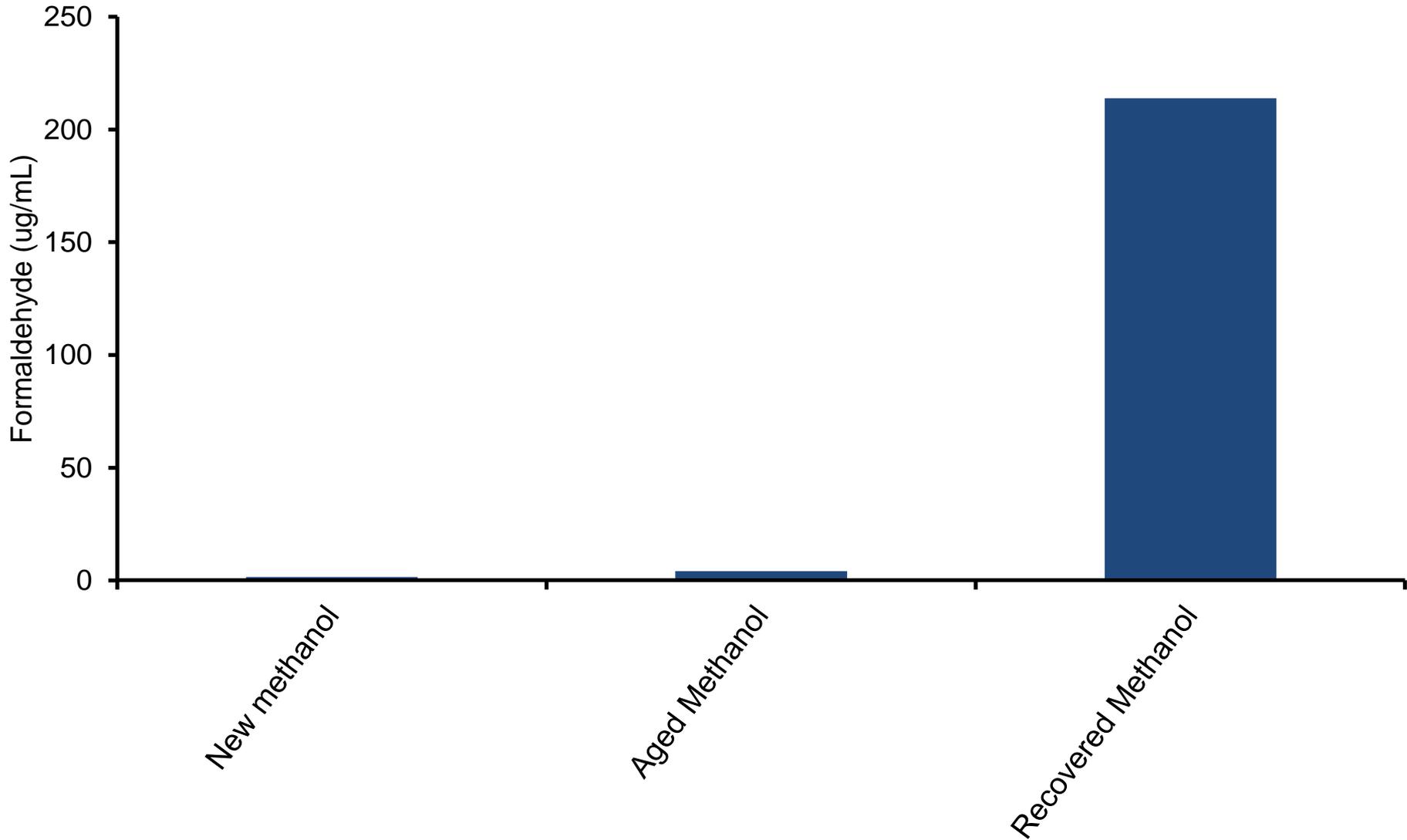
**Glycol Dehydrators:
10-30 $\mu\text{g s}^{-1}$**



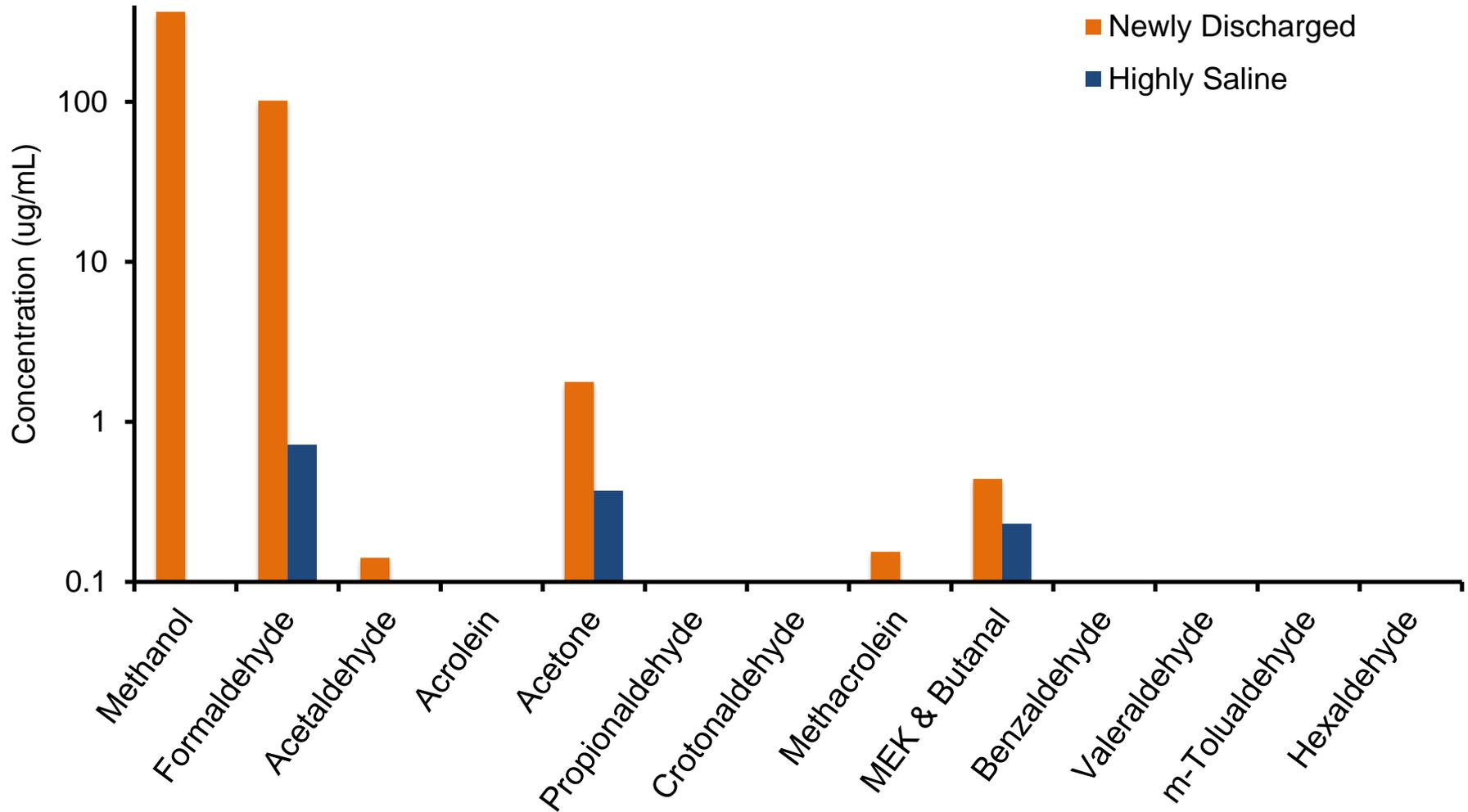
Pipeline



Methanol Accumulates Carbonyls Between Injection and Recovery



Produced Water Contains Carbonyls



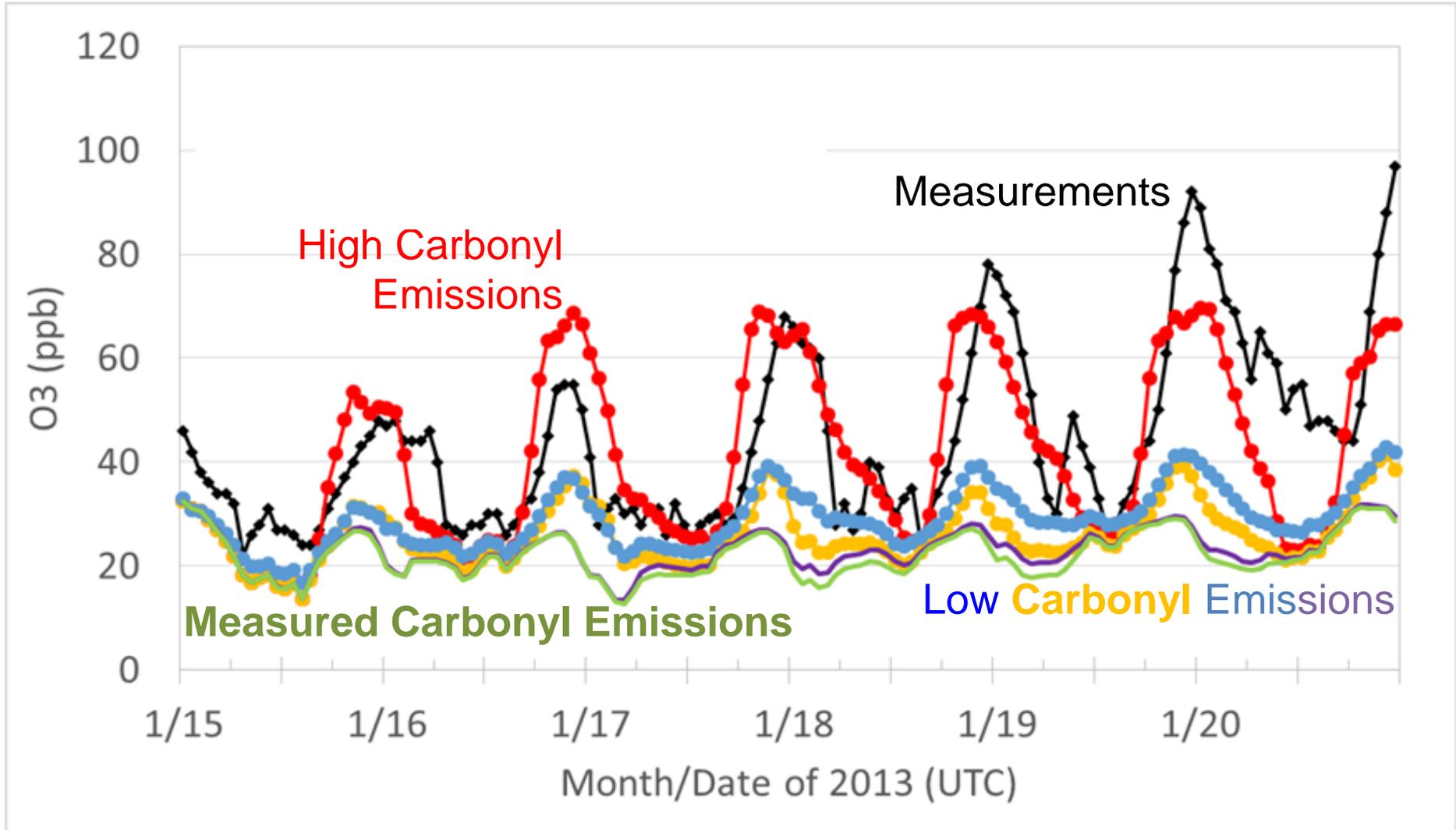
What We Have Learned So Far About Carbonyl Emission Sources

- **Carbonyls are emitted from combustion-related and non-combustion sources**
- **Non-combustion sources emit different carbonyl compounds than combustion sources**
- **Methanol and glycol may help produce carbonyls, but are not required**

What We Still Don't Know About Carbonyl Emission Sources

- **We still lack reliable emissions measurements from many, many sources**
 - **Midstream sources (compressors, processing plants, dehys, etc.)**
 - **Heaters**
 - **Waste streams**
- **Our own measurements are too few to be definitive, more needed**
- **Carbonyl formation in snowpack?**
- **Alcohol decomposition to carbonyls in air?**

Our Measurements Best Match Low-Carbonyl VOC Speciation Profiles



Models May Be Getting High Ozone For the Wrong Reason

