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Current and future work at Stanford on natural gas and methane: NGI, leak simulation, LCA

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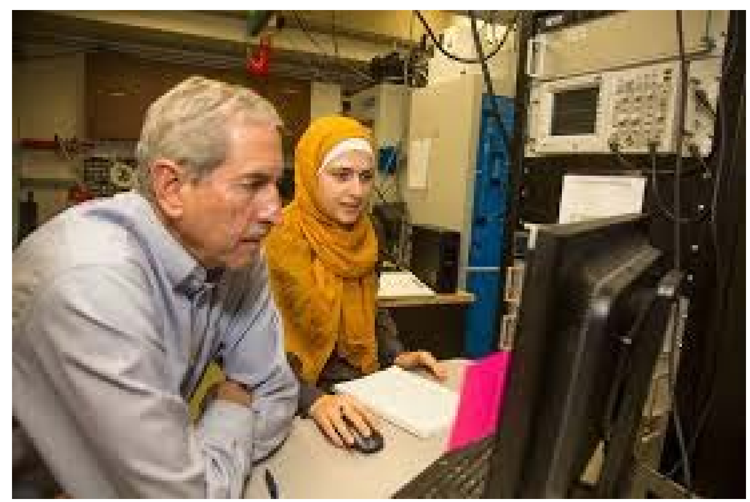
ARB Methane Symposium, June 6th, 2016, Sacramento, CA

Stanford | Natural Gas Initiative
School of Earth, Energy & Environmental Sciences
and Precourt Institute for Energy

energy resources engineering

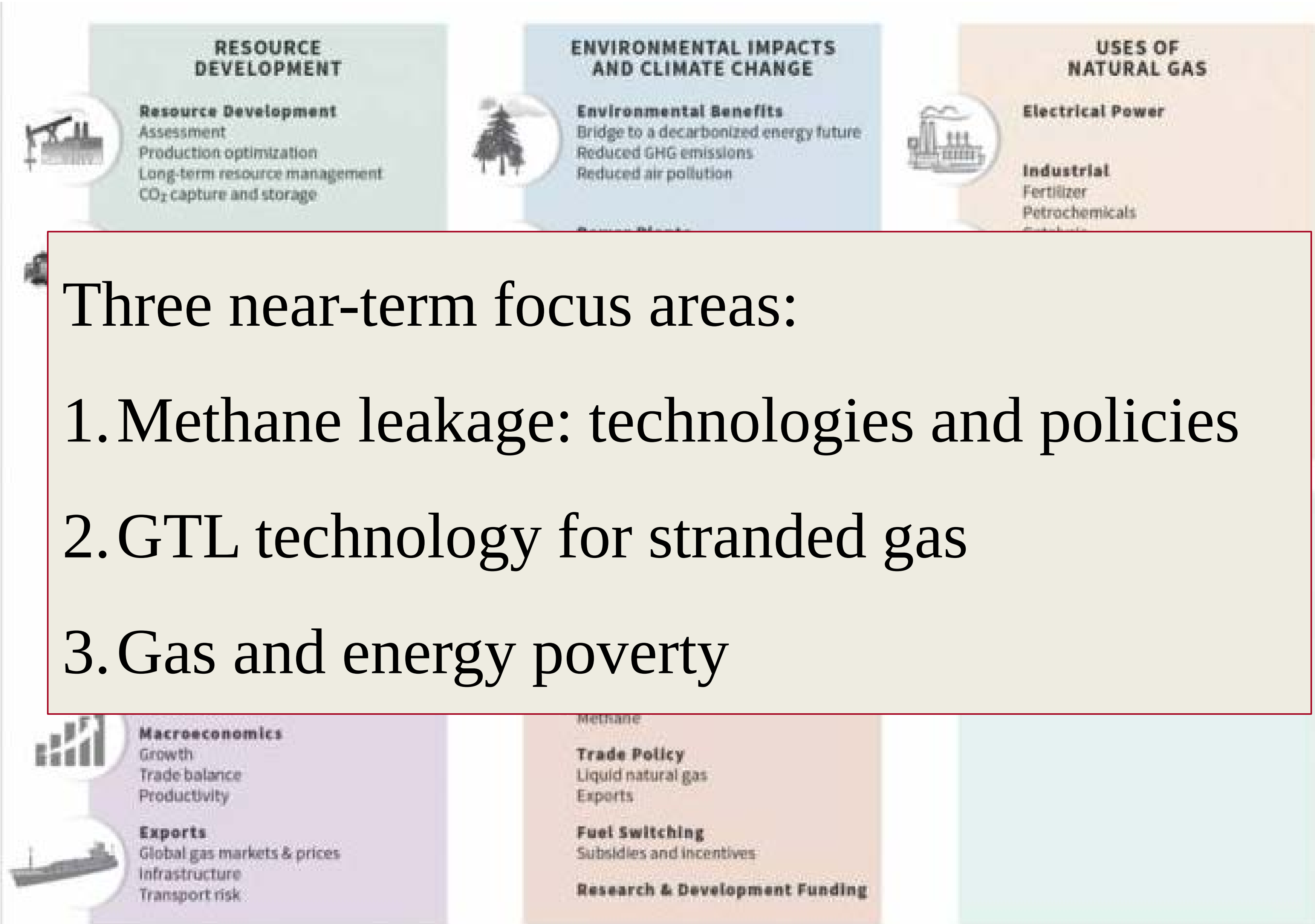
The Natural Gas Initiative

- Interdisciplinary effort at Stanford
- Aims to foster research across all aspects of natural gas
- All Stanford Schools involved
  - Law, Earth Sciences, Engineering



Source: NGI: ngi.stanford.edu

Areas of NGI research



Three near-term focus areas:

1. Methane leakage: technologies and policies
2. GTL technology for stranded gas
3. Gas and energy poverty

What have we learned about natural gas leaks?

1. US methane emissions have increased over last 10 years and are higher than EPA inventories

(Turner et al. 2016)
(Brandt et al. 2014)

(Miller et al. 2013)

2. Some (but not all) excess methane is likely from natural gas sources

3. New studies give insight into sources
   - Lower: Wellpads, G&P, distribution
   - Higher: Pneum., comp., super-emitters

(Allen et al. 2013)
(Mitchell et al. 2015)
(Lamb et al. 2015)
(Allen et al. 2014)
(Zavala-Araiza 2015)
(Subramanian 2015)

4. Challenging to align top-down results with bottom-up inventories
   - Barnett shale & "super-emitting" sources

(Zavala-Araiza 2015)

5. Attention needed on liquids-rich plays
   - Recent work in Bakken shows high leakage rate

(Lyon 2016, Peischl 2016, Kort 2016)

Which questions remain?

1. Which technologies will most effectively detect emissions?

Simulation to compare technology options

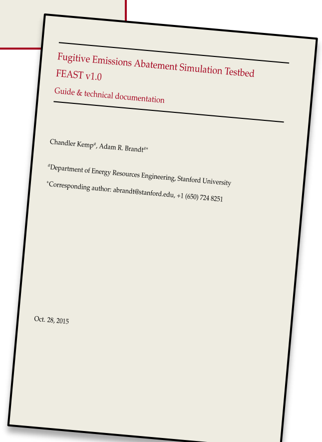
2. How can we include super-emitters in existing life cycle estimates?

Simulation and experimentation to evaluate proposed regulations

How to compare detection technologies?

FEAST:

Fugitive
Emissions
Abatement
Simulation
Toolkit



Fugitive Emissions Abatement Simulation Testbed
FEAST v1.0
Guide & technical documentation

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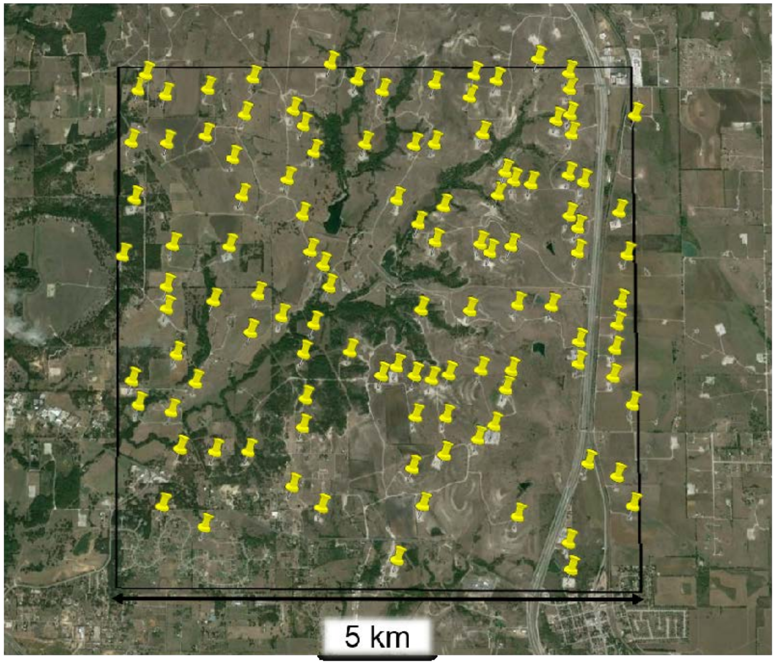
Oct. 28, 2015

- Many detection technologies exist…many more are proposed
- How can we rigorously, fairly, and cheaply compare different ideas?
- We have developed a “virtual training ground” for technologies
- FEAST model is open-source and modular: Anyone can model or update as desired

Source: Kemp, Ravikumar, Brandt (2016).

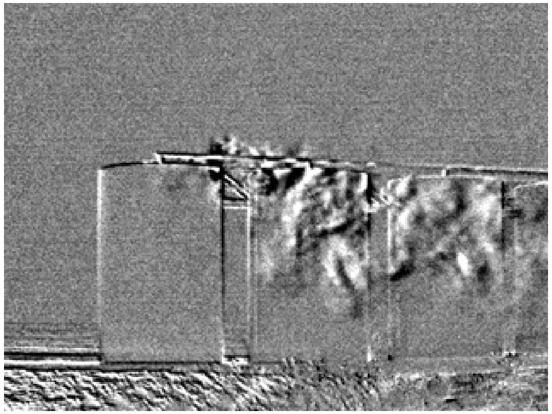
Simulating technologies in FEAST

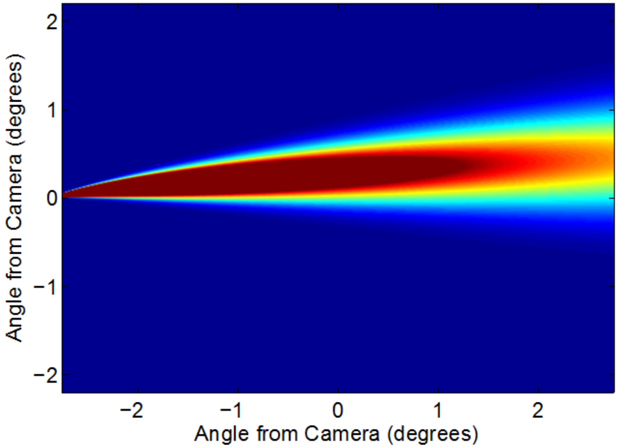
Step 1: Initialize artificial gas field



- Well counts
- Distances
- Equipment counts and components

Step 2: Initialize leaks



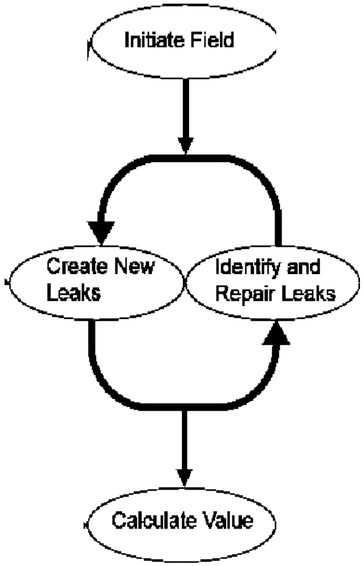


Source: Kemp, Ravikumar, Brandt (2016). Video Englander 2015.

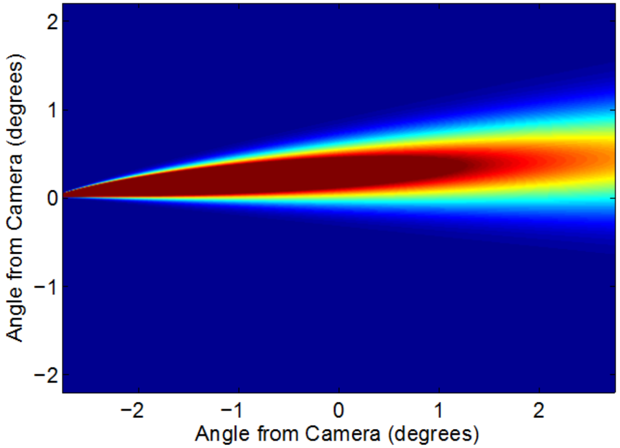
Probabilities of leak generation

Step 3: Add and subtract leaks

- Two-state Markov model
- Probabilities of leaks forming on a given day
- Include background repair rate

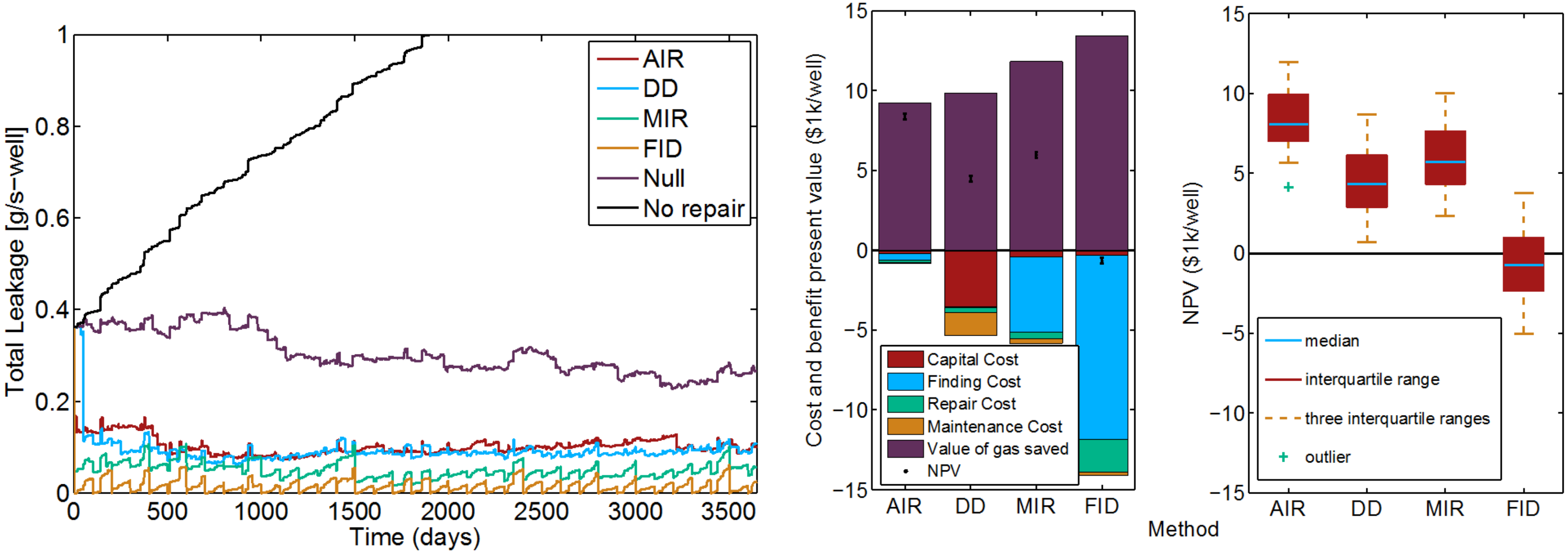


Step 4: Simulate detection tech.



- Which leaks will be detected, given parameters of detection tech?
- Frequency of surveys
- Sensitivity
- Leak size distributions

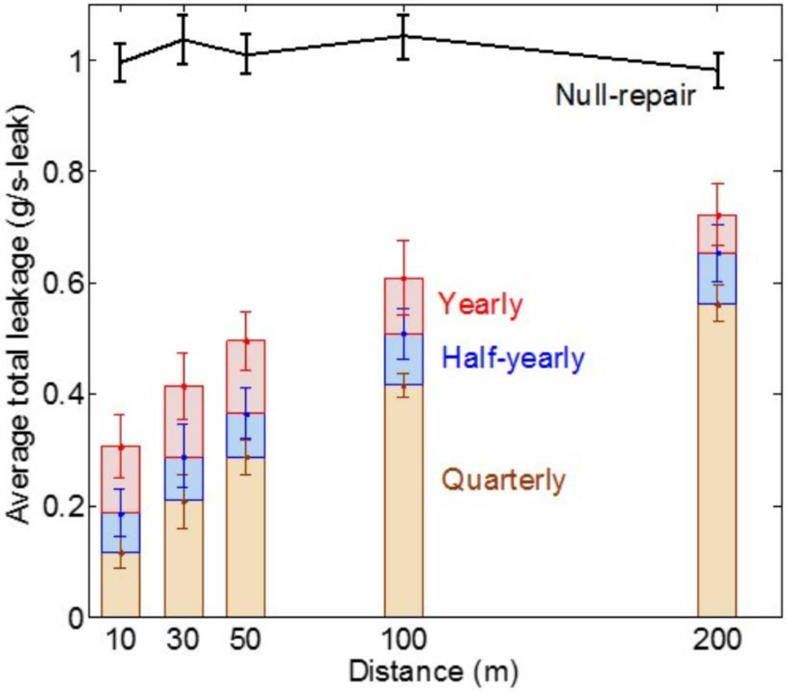
Comparing technologies



Step 5. Compute net benefits from each tech. (NPV)

Simulation and experiments to inform regulation

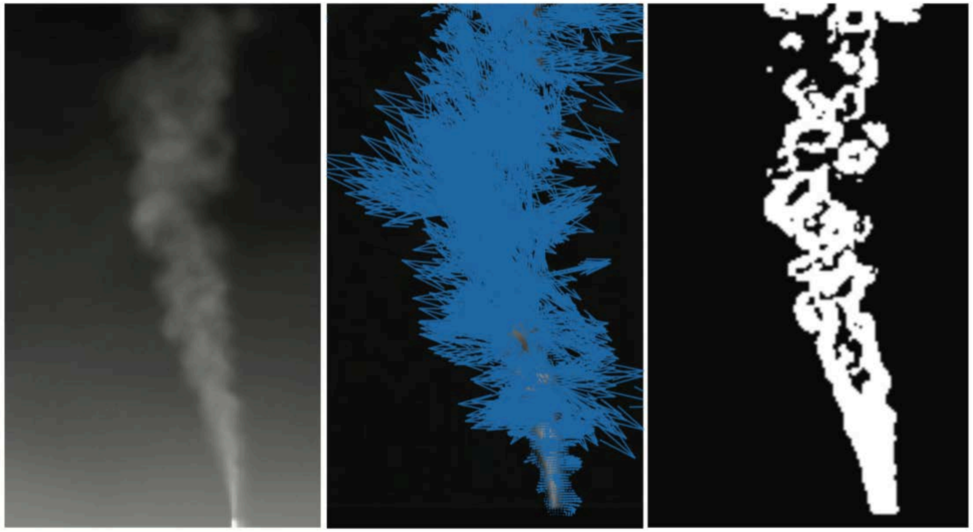
- Can we study the effectiveness of proposed regulation?
- EPA proposed methane rule (Aug 2015):
  - Optical gas imaging (semiannual)
  - Fix leaks within 15 days
  - Frequency of surveys changes based on performance
- How well does this regulatory format perform against an artificial (but statistically representative) gas field?



Illustrative results

Experimental model verification

- Experimental verification of IR camera simulator
- Collaborated on controlled releases
- Measure environmental conditions
- Compare processed video readings to simulation



Plume (left); Optical flow velocity field (middle); Binary image generated using velocity threshold (right)

Source: Ravikumar et al. 2016

Moving forward: Building super-emitters in LCA

- Beginning new project with ARB: building super-emitters into life cycle analysis tools
- Current LCA tools (including those used in transport models such as GREET and OPGEE) do not account for recent experimental results
- Much better datasets now available on fugitive emissions
- How do these affect life cycle choices such as EV or CNG/LNG vehicles?
- How does associated or shale gas differ from conventional gas fields?